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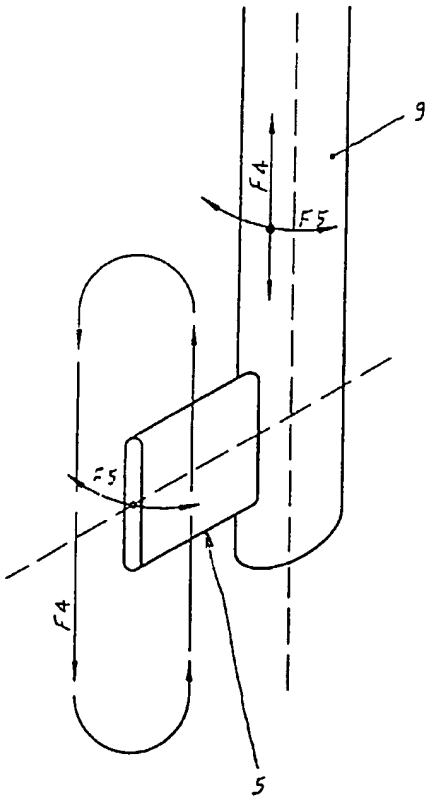
(54) Title: NUMERICALLY CONTROLLED AUTOMATIC WINDING MACHINE FOR WINDING AN ELECTRIC WIRE ON CLOSED SLOT STATORS



(57) Abstract: A machine suited to realise automatically the complete winding of all coils directly on stators with "closed slots", comprising a plurality (A, B, C, Y, E, X, Z, H) of electronically controlled axes. The machine allows to form coils having uniformly arranged turns, which are adjacent to each other and do not mutually cross, wherein the layers are regularly overlapped, thereby ensuring that coils have all the same number of turns, the same length (in meters) of the electrically conductive wire, the same electric resistance; this implies, especially in the realisation of analogue electric motors, a higher efficiency and a more regular operation, and a noticeable reduction of the winding time. The machine is provided with a special needle (5) mounted horizontally on a vertical rod (9). The head portions of the stator (14) are appropriately configured in order to facilitate the winding operation and are used in combination with the machine.

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Description

Numerically controlled automatic winding machine for winding an electric wire on closed slot stators

Technical Field

The present invention relates to a machine suited to automatically perform the complete winding of coils directly on stators with closed slots (inwardly directed pole shoes).

The term "closed slot stator" is used herein for a stator in which the slots, inside which the windings making up the coils are arranged, are disposed internally instead of on the outer periphery (see Fig. 1 which illustrates a stator core lamination for a "closed slot stator", wherein numeral 19 denotes the slots containing the windings).

Background Art

Various types of winding machines (coil winders) suited to wind up electrically conductive wires around a ferromagnetic core in an "open slot stator" are well known in the art. However, until now there are no winding machines suited to automatically and mechanically perform the winding operation on "closed slot stators"; this winding operation with respect to "closed slots" is carried out only manually.

The manual winding of the wire, in case of closed slots, besides being wearisome and requiring specialised staff, also takes much time (and is therefore expensive), and results in turns which are overlapped and crossed, that is randomly disposed, in such a way that for the same number of turns, the length of the wire - expressed in meters – , and therefore its electric resistance, is not the same for all coils; the latter circumstance leading to anomalies in operation especially in applications concerning analogue motors.

Moreover, the efficiency of an electric motor depends on several factors, like the

length of the electric conductor (conductive wire) for a constant value of the volume occupied by the coil turns.

An object of the present invention is to provide users with a machine allowing to automatically perform the complete winding on closed slot stators, without being forced to interrupt the continuity of the conductive wire.

A further object of the present invention is to perform the winding in such a way that the turns are regularly arranged, wherein each turn is adjacent to the other, and the layers are regularly (uniformly) overlapped (in quincunx; staggered) in order to provide inside a given space the maximum number of turns and consequently the maximum length of the electrically conductive wire.

Still another object of the invention is to ensure that the coils are all identical, both with regard to the number of turns and length of the conductive wire, and to the value of electric resistance.

A further not less important object of the present invention is to obtain a perfect winding operation, which may be performed at low cost, repeatedly and always in the same manner, and which is easy, quick and does not require specialised staff.

Disclosure of Invention

The above and further objects are attained by a winding machine according to the present invention, which performs a plurality of movements and automatic operations which are synchronised with respect to each other and are electronically controlled, wherein the machine comprises: a special needle suited to feed and distribute the electrically conductive wire used to form the coil; ferromagnetic stator core laminations used to form the stator core lamination pack, which have a special contour; special head portions which form part of the stator and which make possible to perform a winding operation wherein the turns are uniformly disposed, adjacent to each other, and located on overlapping closely packed layers (in quincunx) with no crossing; a number of eight electronically controlled axes denoted by the letters A-B-

C-Y-E-X-Z-H ; a mechanical assembly which is controlled by the axis "A", moving the needle according to a vertical reciprocating motion combined with a horizontal oscillation or "training" motion; a mechanical assembly controlled by the axis "B", which moves said stator according to a rectilinear reciprocating motion, in order to centre the passage of the needle between the poles; a mechanical assembly, controlled through the axis "C" and synchronised with the axis "B", for increasing or decreasing the amplitude of the oscillation or "training" of the needle; a mechanical assembly controlled by the axis "Y", for horizontally translating said stator in order to obtain the stratification of the turns; a mechanical assembly, controlled by the axis "E", which rotates said stator, in order to pass from the pole shoe whereon the winding has already been completed, to the next pole shoe, whereon the winding operation must be continued without interruption, using still the same electrically conductive wire; a mechanical assembly, controlled by the axis "X", used to longitudinally translate a needle support head; a mechanical assembly, controlled by the axis "Z", performing the vertical translation of the needle support head; a mechanical assembly, controlled by the axis "H", which actuates a fork acting on the wire during its passage from the outside to the inside of the stator slots and vice versa, and which is also used to insert the wire between appropriate hooking means when the wire is laid on the path leading from one pole shoe to the next one to be wound; a tensioning device, for the electrically conductive wire; a service plate, whereon a corresponding indexed pallet is provided for each of a plurality of stators to be "wound" at the same time; a device allowing to lock the stator supporting pallets on corresponding mandrels; a device for automatically anchoring, that is fixing, said conductive wire at the beginning and at the end of the winding operation; a device for automatically cutting the wire at the end of the winding operation; an automatic loading/unloading device including several stations, used for loading/unloading the service plate which supports the pallets; electromechanical means used for the functions of the various moving members;

electronic means used for programming the various axes; a plant for force feed lubrication (pressure lubrication); and safety means against accidents, conforming to the present law.

Brief Description of Drawings

Further features and advantages of the invention will result more clearly from the description of a preferred but non-limitative embodiment, of the winding machine which is shown for illustrative but non-limitative purposes in the annexed drawings, wherein:

Fig. 1 shows, in a plan view, one of the various ferromagnetic stator core laminations of the "closed slot" kind making up the laminar pack of the stator whereon the winding operation is to be performed;

Fig. 2 is a perspective view of the whole assembly forming the winding machine of the present invention;

Fig. 3 shows in more detail the device used for tensioning the conductive wire;

Fig. 4 is a front view of the winding machine;

Fig. 5 is a plan view of the winding machine;

Fig. 6 is a side view of the winding machine;

Fig. 7 schematically shows the movements of the needle dispensing the conductive wire;

Fig. 8 shows according to a perspective view, the upper head portion of the stator;

Fig. 9 shows, according to a perspective view, the lower head portion which completes the stator;

Fig. 10 shows, according to a perspective view, the assembly including the stator, the upper head portion, and the lower head portion;

Fig. 11 shows, in a partially sectional perspective view, the assembly formed by the stator and its head portions, illustrated in Fig. 10;

Fig. 12 schematically shows how a complete winding of the stator includes three terns of coils which are angularly shifted by 120° degrees from each other;

Figs. 13, 14 and 15 respectively illustrate the path of the electrically conductive wire giving rise to the first, second, and third group of terns of regular (that is, uniform) windings, making up the complete winding provided on the stator, as shown schematically in Fig. 12;

Fig. 16 is a plan view of the upper head portion, which is shown in perspective view in Fig. 8, illustrating the appearance of the stratification of the conductive wire in the various coils making up the complete winding;

Fig. 17 is a cross section taken in the plane A-A of Fig. 16;

Figs. 18-23 illustrate, according to different views and/or sectional views, the needle used to dispense the electrically conductive wire or cable; and more particularly:
Fig. 18 is an end view of the needle, in the direction indicated by the arrow F3;

Fig. 19 is a cross-section taken along the line C-C of Fig. 20;

Fig. 20 is a cross section along the line B-B of Figs. 18 and 19;

Fig. 21 and Fig. 22 are enlarged views of Figs. 19 and 18 respectively;

Fig. 23 shows, according to two orthogonal views - one of them being a cross-sectional view - the configuration of the needle at the end where the conductive wire comes out of the needle;

Fig. 24 shows, in cross section, the needle inner structure and how it is inserted on the needle supporting mandrel;

Fig. 25 schematically shows which movements the fork is able to carry out, said fork being apt to guide the electrically conductive wire during its passage from the inside to the outside of the stator slots and vice versa;

Figs. 26 and 26/bis show two possible positions, inside the stator, of the needle used to dispense the conductive wire;

Figs. 27 – 28 illustrate, according to two orthogonal views, a mechanical hand and the associated turntable, which may be optionally actuated to automatically replace the pallet support plates, which, in the illustrated embodiment, serve for holding 4 stators;

Fig. 29 illustrates in detail the pallets and pallets support plate;

Fig. 30 schematically shows the mechanical assemblies used to transmit a rectilinear reciprocating motion to the stator, and to increase or decrease the amplitude of the needle oscillation or "training motion";

Figs. 31, 32 and 33, schematically show an alternative solution according to which the orthogonal displacements, normally carried out by the stator support carriage, by means of the axes X-Y, are now obtained by the displacement of the needle itself;

Fig. 34 illustrates both in detail and in cross-section, the modular elements used to maintain the electrically conductive wire in a tensioned condition;

Fig. 35 is an end view, in the direction of the arrow F6, of the tensioning device of Fig. 34, showing how the tensioning elements are arranged according to different inclinations.

Best Mode of Carrying out the Invention

In the various figures, the same alphanumeric reference characters denote the same elements or parts.

The winding machine shown in the various annexed drawings is a machine which performs simultaneously the winding operation of four stators.

In some figures, some details have purposely been omitted in order to render more clearly understandable the features to be emphasised, this has been done to the effect of making the description clearer and more concise; moreover, the annexed drawings neither include conventional structural elements, nor mechanical assemblies which are known and/or evident to a skilled person.

The machine according to the present invention, is characterised by the following basic components:

a) a structure or machine base 1 (Fig. 6) supporting and grouping or connecting together the single assemblies, according to the desired configurations and positions;

b) a carriage 2, movable horizontally along guides, in the directions indicated by the double arrow F1 (Fig. 6) (this movement being controlled by the axis Y), wherein said carriage supports the mandrels 3 which are motor driven and controlled by the

axes B and E; the pallets supporting the stators to be "wound", are locked on these mandrels;

c) a carriage 4 (Fig. 6), movable vertically along guides, in the directions indicated by the double arrow F2 (this movement being controlled by the axis Z), wherein this carriage 4 supports:

- a needle support head, movable longitudinally along guides, whose movement is controlled by the axis X;
- the needles 5, dispensing the electrically conductive wire, whose movements are controlled by the axis A and C;
- the forks 6, which may act on the conductive wire by guiding it during the winding steps and during the displacement from one pole to the next, said forks being controlled by the axis H;

d) a device 7 (Figs. 2, 3, 34, 35) for tensioning the electrically conductive wire;

e) a service plate 34 (Fig. 29), carrying the indexed pallets 35 used to support the stators 14 to be simultaneously wound;

f) a device allowing to lock the pallets 35 supporting the stators 14, on the respective mandrels 3 (Fig. 6 and 29);

g) a device (optional), located near each pallet 35, used to automatically anchor thereon said electrically conductive wire;

h) a device (optional) used to automatically cut the conductive wire, arranged near each pallet;

i) an automatic mechanical hand 37 (Figs. 27 and 28), or robot (optional), including several stations, suited to replace said service plate carrying the stators and pallets;

l) a cabinet containing all necessary electric, electronic and pneumatic apparatus realised according to known configurations;

m) a console for control purposes;

n) the relevant programming software;

o) all necessary circuits suited to obtain the required functions, realised according to known configurations;

p) the required lubrication circuits, realised according to known configurations;

q) safety means against accidents, realised according to the law existing in the country where the winding machine is used;

The needle 5 (Fig. 6) which feeds the electrically conductive wire 8 is shown in detail in Figs. 18 to 25 and is characterised in that it has a central hole 43 (Figs. 20, 21), whose diameter is chosen according to the diameter of the wire being used, and said hole, both at the inlet and outlet is widely rounded in all directions, according to radii which are related to the wire diameter. Figs. 23 and 24 show how the needle 5 can be inserted on the needle carrying rod 9; the arrows F9 and F10 (Fig. 23) indicate the directions along which may slide the electrically conductive wire. In Fig. 7, the various arrows indicate the movements imparted to the needle 5:

- arrow F4 = vertical reciprocating motion;
- arrow F5 = "training" movement; it should be noted that the mechanical assemblies required for these movements are neither shown nor described, since they only require ordinary skill and common knowledge.

Moreover, in Fig. 24 and 25 other details are shown.

For instance, at the lower end of the rod 9 carrying the needle 5, there is provided, according to known configurations, an elastically biased take-up device 44 like those used in the textile industry, whose function is to compensate the varying amount of wire length required during the winding operation; moreover, there is the need to provide guide bushes 45 for the wire, arranged inside the rod 9.

All mentioned mechanical assemblies could be realised in any known form whatever, and are synchronised with respect to each other and apt to move each component of the machine according to electronic programs specified by custom-made software. Specifically, the machine comprises several parts which will now be described in more detail.

The ferromagnetic core laminations (Fig. 1) which form the stator 14 (Fig. 10) to be "wound", have poles 20 with inner ends provided with recesses or seats 10; the teeth 11 of the head portions 12 (Fig. 8, upper) and 13 (Fig. 9, lower) are introduced in said seats 10, in order to complete the assembling of the stator 14, during which said head portions are inserted on the two ends of the stator 14, as shown in Fig. 10; the purpose is to obtain a stable orientation of the head portions 12 and 13 with respect to the pole shoes of the stator 14.

Said head portions 12 and 13 are moulded using thermoplastic material (or in any case in a non-ferromagnetic material), and have the function to facilitate and make the winding operation possible.

The upper head portion 12 (Fig. 8, 16 and 17), besides having its reference teeth 11 located on the lower part of the inner end of respective arms 15, shaped according to the configuration of the pole shoes of the stator, is also characterised by the following features:

a) the length "l" of the inner contour of the arms 15 (Fig. 16) is a multiple of the conductive wire diameter to be wound in a uniform manner;

b) the inner contour 16 of the arm ends 15, is shaped so that it will be possible to contain an integer number of turns for each layer overlapping the underlying layers, taking account of the fact that the turns of each layer comprised in a coil 17, are arranged in an ordered, closely packed manner, optimising the available space, as shown in Figs. 16 and 17 (the Italian and French terms for this arrangement is "quinconce", the English term is "quincunx ", meaning staggered or "zig-zag");

c) a plurality of projecting fins 18, is arranged on a circumference, and is centred and introduced inside the ends of the core laminations pack 14 (Fig. 8), coming in contact with the external diameter "De" of the slots 19 which separate the pole shoes 20 from each other (Fig. 1).

d) It has an annular configuration wherein the external part is circular and the internal part is polygonal, the number of sides 21 corresponding to the number of

pole shoes of the stator to be wound (Fig. 16).

e) It has as many arms 15 as sides of the polygonal part.

f) It has a groove 22 (Figs. 8 and 16), realised on each side of the polygon, in proximity of the insertion site of the arms 15.

g) A plurality of fins 23 (Fig. 8 and 16), projects from the opposite side with respect to the alignment or matching fins 18, wherein the number, positions and dimension of the former fins, are selected (see Fig. 13) in such a way as to allow: the hooking of the conductive wire in the starting position 25 of the winding, the winding of the first coil 26 onto the pole shoe 27, the translation of the wire 8 as far as the polarity 28, the winding of the wire to form the coil 29, the translation of the wire 8 as far as the polarity 30 in order to form the coil 31, the exit of the wire at 32, and the hooking of the conductive wire 8 to an appropriate fin (not shown); thereafter, the wire enters again at 33 (Fig. 14), and the same operation is repeated in order to wind the second tern of uniformly and regularly wound coils, and finally, the same operation is repeated for the third tern of coils (Fig. 15).

At the end of this operation, the configuration shown in Fig. 12 is obtained.

In fact, the electrically conductive wire is not directly wound on the metallic pole shoes of the stator 14, but onto the sides (apexes) 38, 39 (Fig. 11) of the arms 15 of the upper head portion 12 and lower head portion 13 respectively, which are inserted on the ends of the stator body 14.

The configuration of said head portions, as shown in Figs. 16 and 17, allows to form uniform layers of coil turns, as illustrated in Fig. 17.

The lower head portion 13 (Fig. 9) is also characterised in that it has a plurality of teeth 11, fins 18 and arms 15, whose size and form are identical to those of the upper head portion 12.

The configuration of the device 7 (Fig. 3) for tensioning the electrically conductive wire 8 is shown in Figs. 34 and 35, wherein 46 denotes the inlet hole or passage of the conductive wire, and 47 the outlet wire guide, whereas numeral 48 indicates a

plurality of tensioning apparatus which are all characterised by a small disk 49, which may be stationary or rotatable around a central pin, said small disk being mounted, in a radial direction, in contact with the conductive wire 8; moreover, each tensioning apparatus comprises a small disk 50, which is stationary or rotatable, which may be made to approach the conductive wire 8, and, by using a mechanical or pneumatic spring, whose pushing force can be calibrated, can be used to apply a friction force on the conductive wire when the latter slides between said two disks 49, 50. The devices 48, which are assembled as separate modules, are not aligned, but have different inclinations, as shown in Fig. 35, so as to prevent the conductive wire 8 from being subjected to a frictional force always on the same surface, at each tensioning device, with the risk of eroding the insulating layer of the wire 8. The closing force by which the disks 49, 50 retain the wire 8, besides being adjustable, will be very small and is calibrated according to the diameter of the wire 8.

The operation of the device according to the present invention will now be described. The operator mounts corresponding head portions 12, 13 on four respective stators 14; then, he prepares, outside the machine, the service plate 34 (Fig. 29), by placing thereon four indexed stator supporting pallets 35 with four corresponding stators 14; thereafter, he puts on the machine the plate 34, using appropriate reference pins 40 for determining its correct position. The axes B-E-Y, disposed in the "zero" position, allow the simultaneous introduction of the four pallets 35 on the respective mandrels 3, which are provided with a locking ring nut 58.

Then, the operator pushes the start button, whereby:

- four pneumatic latches 41, by preventing initially the rotation of the ring nuts 58 used for locking the stators, allow the automatic "hooking" of the pallets on which the stators have been mounted, by means of the mandrels 3 which are set in rotation;
- the four wire guiding forks 42 (Fig. 25) associated to the needles 5, move downwards to a position astride the conductive wire 8, being thereby ready for the first connection (Fig. 13);

- the wire 8, by a combined action of the axis A-Y-E-X-Z-H, is inserted in the inlet connector 25, is guided and inserted in the slot 22 obtained on the upper head portion 12, and is prepared for the winding of the first coil 26;

- the wire guiding forks 42 move upwards, away from the wire, and the machine realises the winding operation automatically, forming a stratified winding 26, according to a predetermined program;

- the wire guiding forks 42 move downwards again, and through a combined movement of the axes A-Y-E-X-Z-H they guide the conductive wire and introduce it in the proper seats, up to the second pole 28;

- the forks 42 move upwards a second time;

- the stratified coil 29 is formed;

- the steps are repeated until the third coil 31 is wound, and this completes the first tern of coils;

- the wire guiding forks 42 move downwards again, thereby engaging the conductive wire 8, and through a combined motion of the axes A-Y-E-X-Z-H they guide and hook the conductive wire in the proper seats formed on the upper head portion 12, they hook it inside the outlet connector 32, and after having laid the conductive wire along a so-called "service path", they prepare it for a the second connection 33 (Fig. 14);

- the winding of the second and third terns of coils is then performed as previously described;

- when the winding is completed, the axes B-E-Y return to their "zero" position (start position);

- the latches 41 lock the ring nuts 58 again;

- the axis E rotates anticlockwise by 1/3 of a complete revolution, thereby unlocking the stator supporting pallets, and comes to rest in the "zero" position;

- the operator cuts the conductive wires associated to each stator, in proximity of the latter, and winds up the portions of wire projecting out of the needles, on an

appropriate service peg or post;

- the operator unloads the service plate 34 carrying the already wound stators and the respective pallets;

- and he puts four new stators to be wound, on a new service plate 34, thereby starting a new cycle.

As mentioned above, the machine may be equipped with.

- a device for automatically cutting and hooking the conductive wire;

- a device for the automatic loading/unloading - comprising several stations - for the service plates 34 and their respective pallets and stators.

The invention, as disclosed, may be modified in different ways, which are all covered by the same inventive concept; moreover, all details may be replaced with other ones, which are technically equivalent.

Claims

1) Digitally controlled winding machine, suited to uniformly wind electrically conductive wires directly on closed slot stators, characterised in that it comprises a special needle suited to feed and dispense the electrically conductive wire used to realise the winding; ferromagnetic core laminations used to form the stator pack, having a special contour, special head portions which complete the stator and which allow to effect the winding with turns disposed regularly in adjacent positions, and overlapping layers arranged in a staggered manner, without crossings; a plurality of electronically controlled axes A-B-C-Y-E-X-Z-H; a mechanical assembly controlled by the first of these axes, A, which moves the needle according to a vertical reciprocating motion which is combined with a horizontal oscillatory or "training" motion; a mechanical assembly, controlled by the second of said axes, B, which moves the stator according to a rectilinear reciprocating motion, in order to centre the passage of the needle between the poles; a mechanical assembly, controlled by a third of said axes, C, which is synchronised with respect to the second axis B, in order to increase or decrease the oscillation or training amplitude of the needle; a mechanical assembly, controlled by a fourth axis, Y, for translating the stator horizontally in order to perform the stratification of the turns; a mechanical assembly, controlled by a fifth axis, E, which rotates the stator, in order to pass from the pole shoe, on which the winding operation has been completed, to the next pole shoe, on which the winding is continued without interruption of the wire continuity; a mechanical assembly, controlled by a sixth axis, X, which performs the longitudinal translation of a needle supporting head; a mechanical assembly, controlled by a seventh axis, Z, which realises the vertical translation of the needle supporting head; a mechanical assembly, controlled by an eighth axis H, which actuates a fork acting on the wire during its passage from the outside to the inside of the stator slots, and vice versa, and which is suited to insert the conductive wire

between appropriate hooking means, along the path leading from one pole shoe to be wound, to the next pole shoe; a tensioning device of the electrically conductive wire; a service plate, on which an indexed pallet is loaded for each stator to be wounded at the same time; a locking device, allowing to lock/unlock a plurality of stator support pallets on respective mandrels; an automatic wire anchoring device, for anchoring the wire at the beginning and end of the winding operation; an automatic wire cutting device, for automatically cutting the wire at the end of the winding operation; an automatic loading/unloading device, including several stations, for said service plate supporting said pallets; electromechanical means, suited for the functions to be performed by the various moving members; electronic means, suited for programming the various axes; a pressure lubrication plant; and safety means for protection against accidents, conforming to the law in force.

2) A winding machine according to claim 1, wherein said special needle used to feed and dispense said electrically conductive wire, comprises:

a needle nozzle (5), which is arranged with horizontal axis, which dispenses the electrically conductive wire (8);

a hollow rod (9), supporting said needle nozzle (5), and disposed with its axis extending vertically,

a wire take-up (44), suited to compensate the varying amount of required wire length in the unit of time, during the winding step, and which is arranged at the lower end of said hollow rod (9); and

guide bushes (45) for the wire (8), mounted inside said hollow rod (9).

3) A winding machine according to claim 2, wherein two movements are imparted to the rod (9) supporting the needle nozzle (5), that is a reciprocating movement in the vertical direction F4, and a rotational reciprocating movement, or "training" F5.

4) A winding machine according to claims 2 and 3, wherein said vertical and rotational reciprocating movements, imparted to said hollow rod (9), are obtained using mechanical assemblies realised in any known configuration.

5) A winding machine according to claim 2, wherein said needle nozzle (5) has the following features:

it has a shape and size suited to be inserted between the poles of the stator to be provided with the windings;

it has an inner hole, such that:

- its cross section is variable in all directions;
- it has a size which is adapted to the size of a wire to be wound;
- it is rounded at the wire inlet portion, corresponding to the diameter of the wire;
- it is rounded as much as possible at the wire outlet portion.

6) A winding machine according to claim 1, wherein said ferromagnetic core laminations which form the stator to be wound, are provided, at the inner end of the pole shoes, with seats or recesses (10) receiving respective teeth (11) formed on the head portions (12 and 13), in order to retain said head portions, maintaining their orientation with respect to the pole shoes of the stator.

7) A winding machine according to claim 1, wherein there are two of said head portions, that is an upper (12) and a lower one (13), which are suited to be inserted and retained at the respective two ends of the stator (14) to be wound, in order to obtain a winding without crossings.

8) A winding machine according to claim 7, wherein the upper head (12) is characterised by :

- an annular structure with dimensions adapted to the size of the stator whereon it

will be inserted;

- said annular structure being externally circular and internally polygonal, and comprising a number of sides corresponding to the number of pole shoes of the stator;

- inner arms (15), whose number corresponds to the number of pole shoes of the stator, extending from the centre of each polygon side and protruding towards the centre, and conforming substantially, with regard to their size and shape, to the size and shape of said pole shoes;

- a plurality of teeth (11) obtained and arranged on the lower part and inner end of said arms (15), having size and shape suited for their insertion inside the seats (10) formed on the ferromagnetic core laminations which make up the stator;

- a plurality of protruding fins (18), arranged along a circumference, on the same side where the teeth (11) are formed, said fins being apt to be aligned and introduced in one end of the laminar pack (14) making up the stator to be wound, and coming in contact, with a small play, with the external diameter "De" of the slots (19) separating the pole shoes (20) from each other;

- a groove (22), formed on each side of the polygon, near to the point where each arm (15) is inserted, and apt to receive the electrically conductive wire;

- a plurality of fins (23), protruding from the opposite side with respect to the alignment fins (18), and whose number, size and positions, are suited to allow the hooking of the conductive wire (8) in the starting position (25) of the winding, and to retain the wire in a correct position, while the latter is translated along a zig-zag path, from one pole to the next pole of each coil tern.

9) A winding machine according to claim 7 and 8, wherein the lower head portion (13) differs from the upper head portion (12), in that it does not comprise any wire hooking fins (23) and grooves (22).

10) A winding machine according to claims 7, 8, 9, wherein the shape, space and dimension of the seats where the coil turns are received, are such that an integer number of coil turns may be comprised in each layer, and each layer can be overlapped to the other ones with a quincunx arrangement of the turns with respect to each other.

11) A winding machine according to claims 7, 8, 9, wherein the upper and lower head portions (12, 13) can be realised according to any known manufacturing method, using a non magnetic material, preferably an electrically insulating material, like thermoplastic or thermosetting materials.

12) A winding machine according to claim 1, wherein the winding operation is not performed directly on the ferromagnetic laminations pack which form a conventional stator, but directly on the arms (15) of said upper and lower head portions (12, 13), after their insertion on the laminar pack, defining an assembly which forms the real stator on which the winding operation is performed.

13) A winding machine according to claim 1, wherein said controlled axes are apt to govern respective mechanical assemblies, which actuate and move the various members of the winding machine, which are suited to carry out automatically the winding operation in conformity with predetermined winding programs.

14) A winding machine according to claim 13, wherein the software for programming the controlled axes is realised following known standards, but is dedicated to the purpose of the present winding machine.

15) A winding machine according to claim 1, wherein the various mechanical assemblies which realise, move, and are used to motorise the devices employed to

feed and dispense the electrically conductive wire and to perform the winding operation, may all be realised in any known form.

16) A winding machine according to claim 1, wherein said mechanical assembly controlled by the axis H, imparts to a fork (42) arranged with a vertical axis, a vertical reciprocating motion F2 and a rotational reciprocating motion F8.

17) A winding machine according to claim 16, wherein said fork (42) can engage the electrically conductive wire (8), and in combination with other controlled axes, it is suited to guide the wire along a zig-zag path, during its passage from the outside to the inside of the stator slots and vice versa, and during its hooking at the beginning and end of the winding operation.

18) A winding machine according to claim 1, wherein said tensioning device of the electrically conductive wire comprises modular elements (48), each including two small disks (49, 50) facing each other, one of them being aligned and in contact with said conductive wire (8), and the other being axially movable and biased by means of a mechanical or pneumatic spring, in order to act on the conductive wire by a frictional force during its passage between the small disks.

19) A winding machine according to claim 18, wherein the modular elements (48) are assembled according to different inclinations.

20) A winding machine according to claim 1, wherein said service plate carrying one or more stator supporting pallets, may be manually inserted or extracted by the operator from its position of use, or may be manipulated automatically by a loading/unloading device which is realised according to any known configuration.

21) A winding machine according to claim 1, wherein said device (41, 58) allowing to lock and unlock, on or from the mandrels, said stator supporting pallets, may be realised according to any known form, and its movements are synchronised with the movements of the electronically controlled axes.

22) A winding machine according to claim 1, wherein said automatic wire anchoring and cutting devices, operating at the end of the winding operation, are realised according to any known form, and their intervention is synchronised with the movements of the electronically controlled axes.

23) A winding machine according to claim 1, wherein said electromagnetic, electronic, pneumatic and lubrication means, may be realised according to any known configuration taking account of the required function.

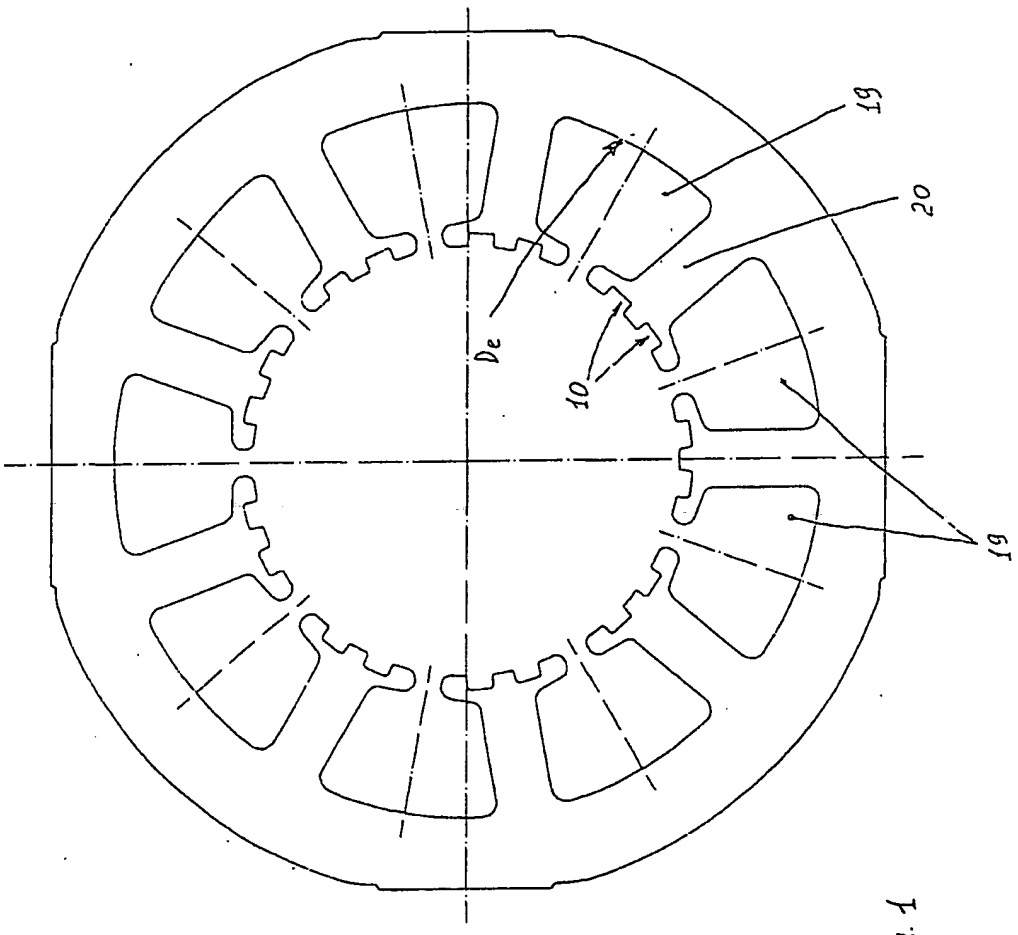


Fig. 1

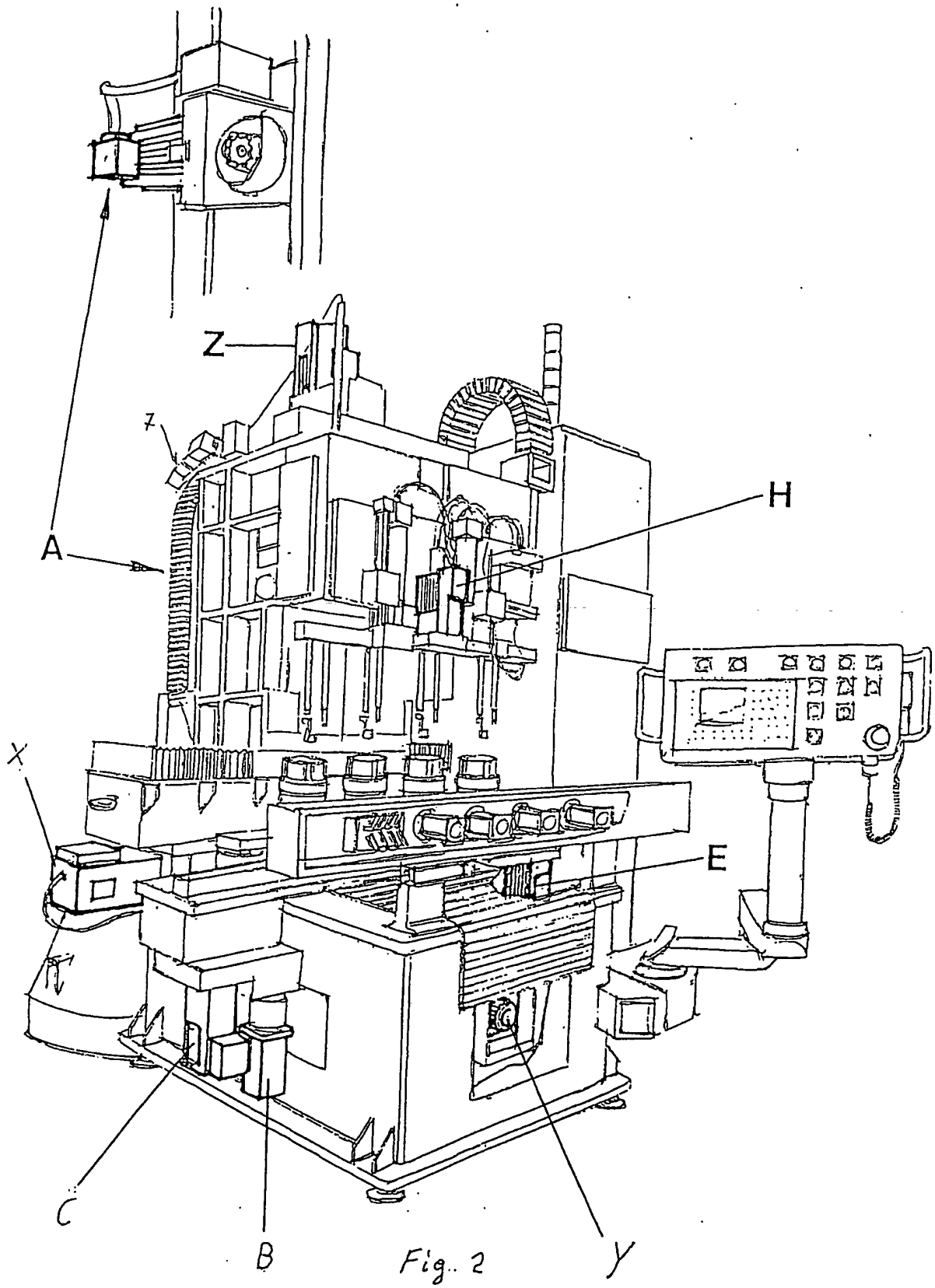


Fig. 2

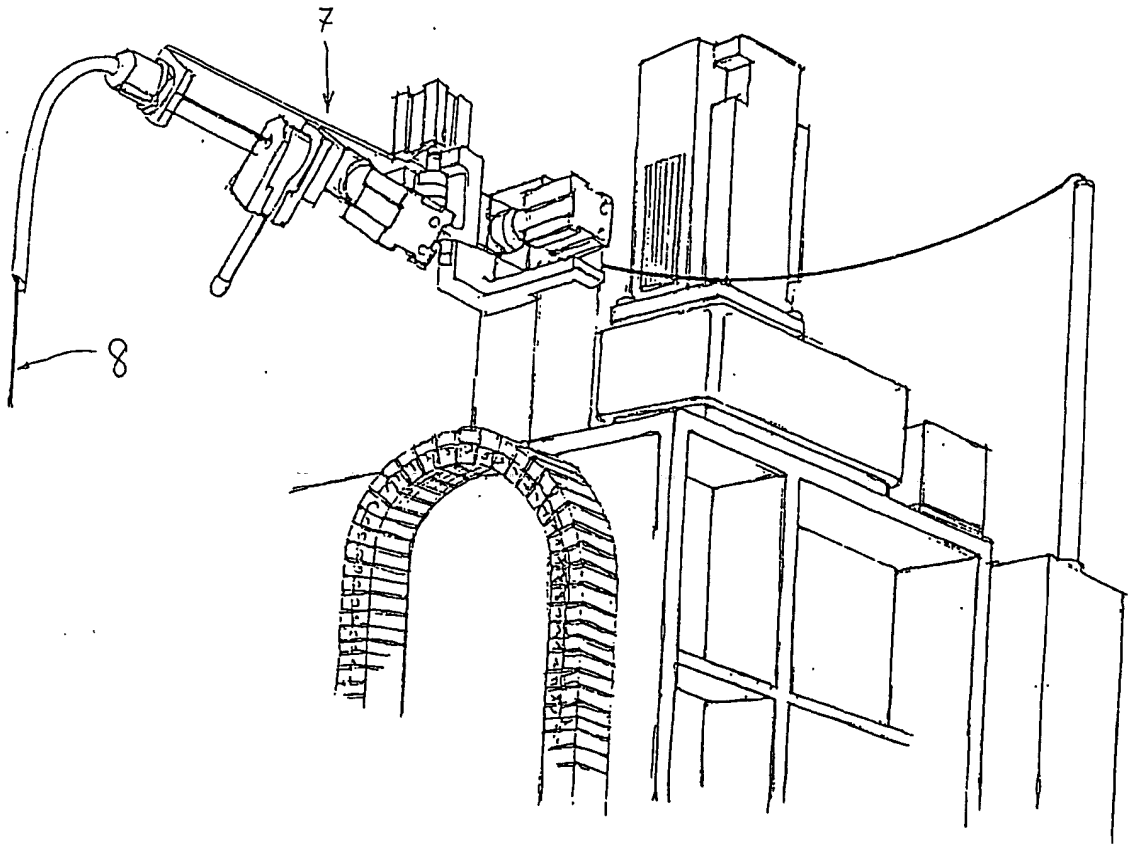


Fig. 3

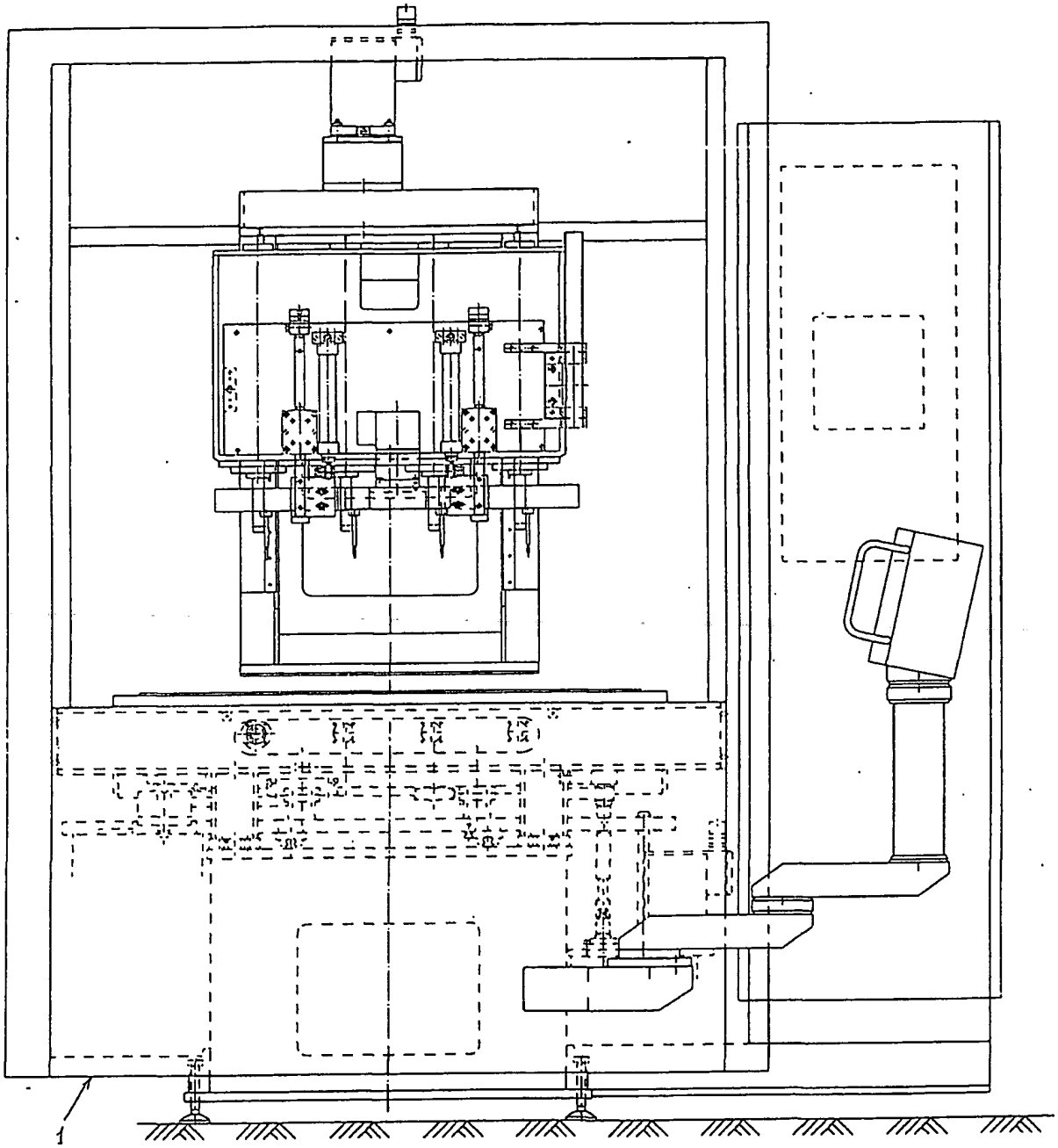
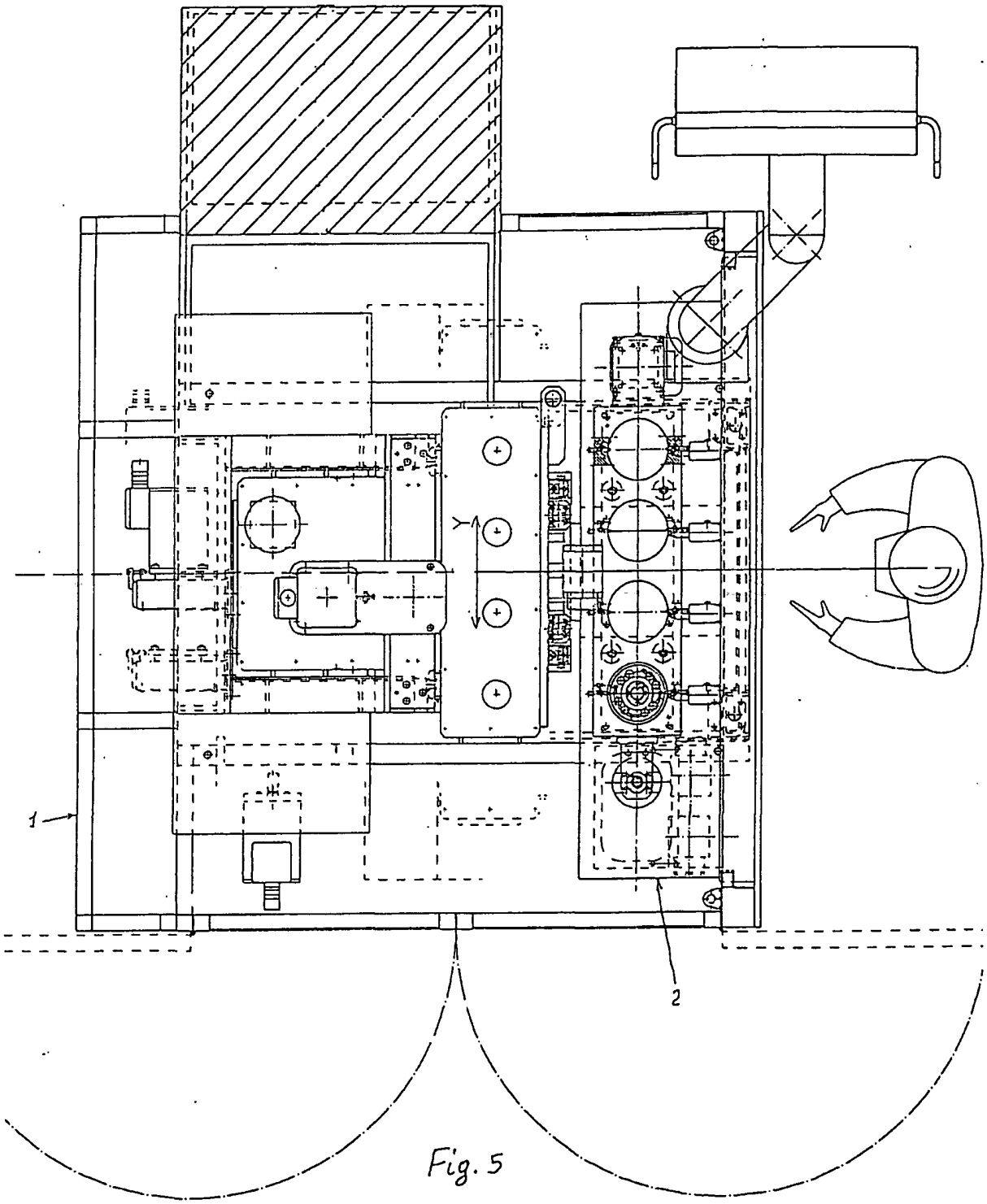


Fig. 4



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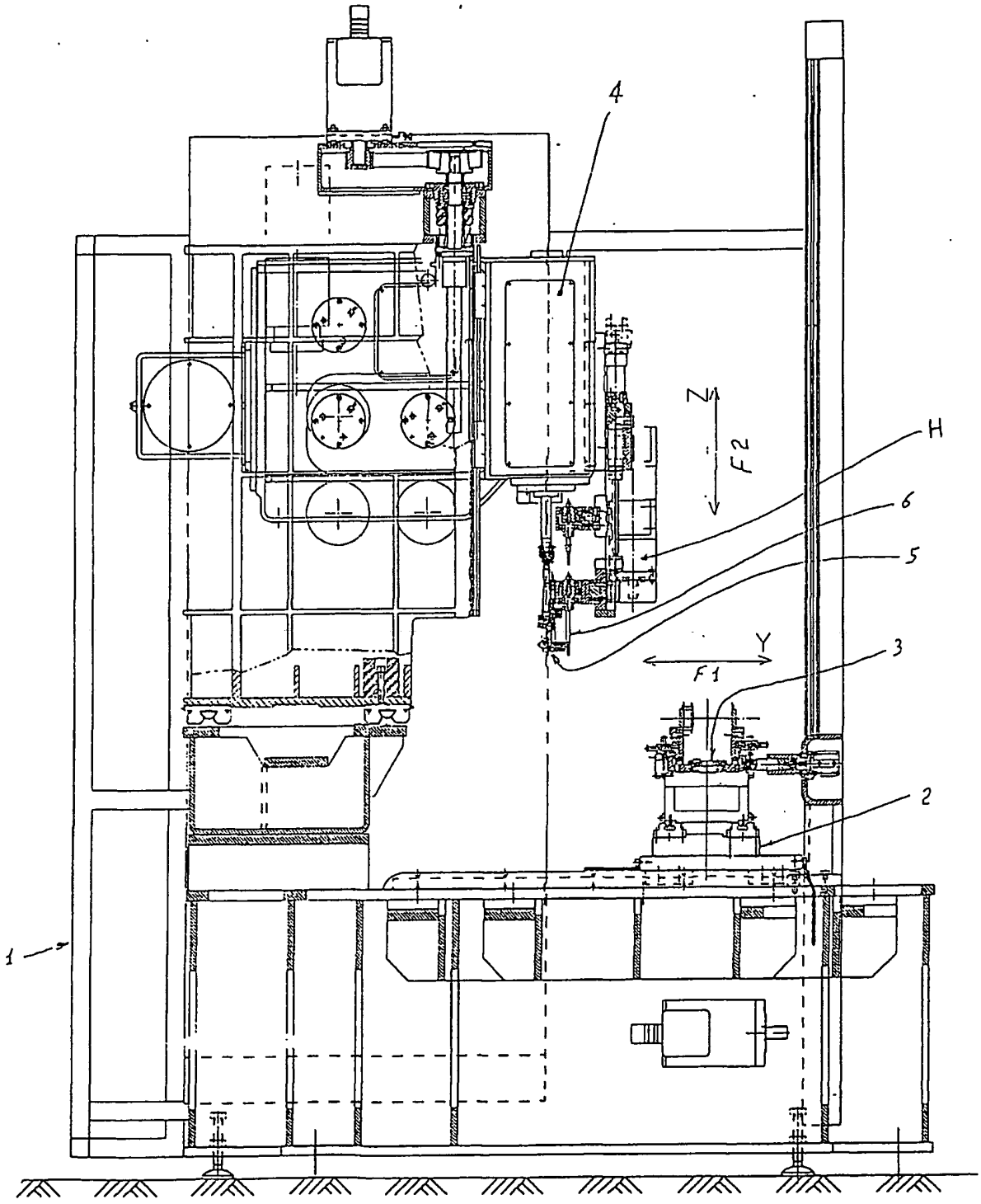

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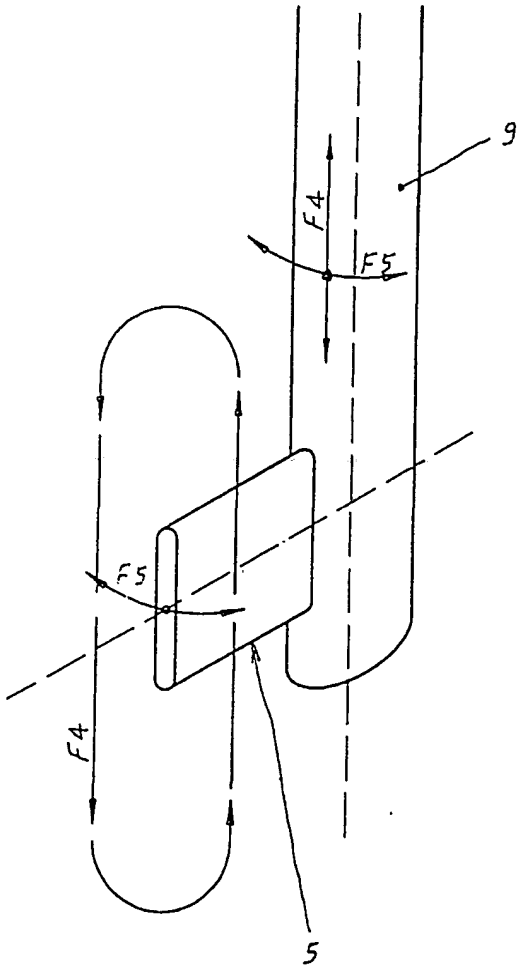

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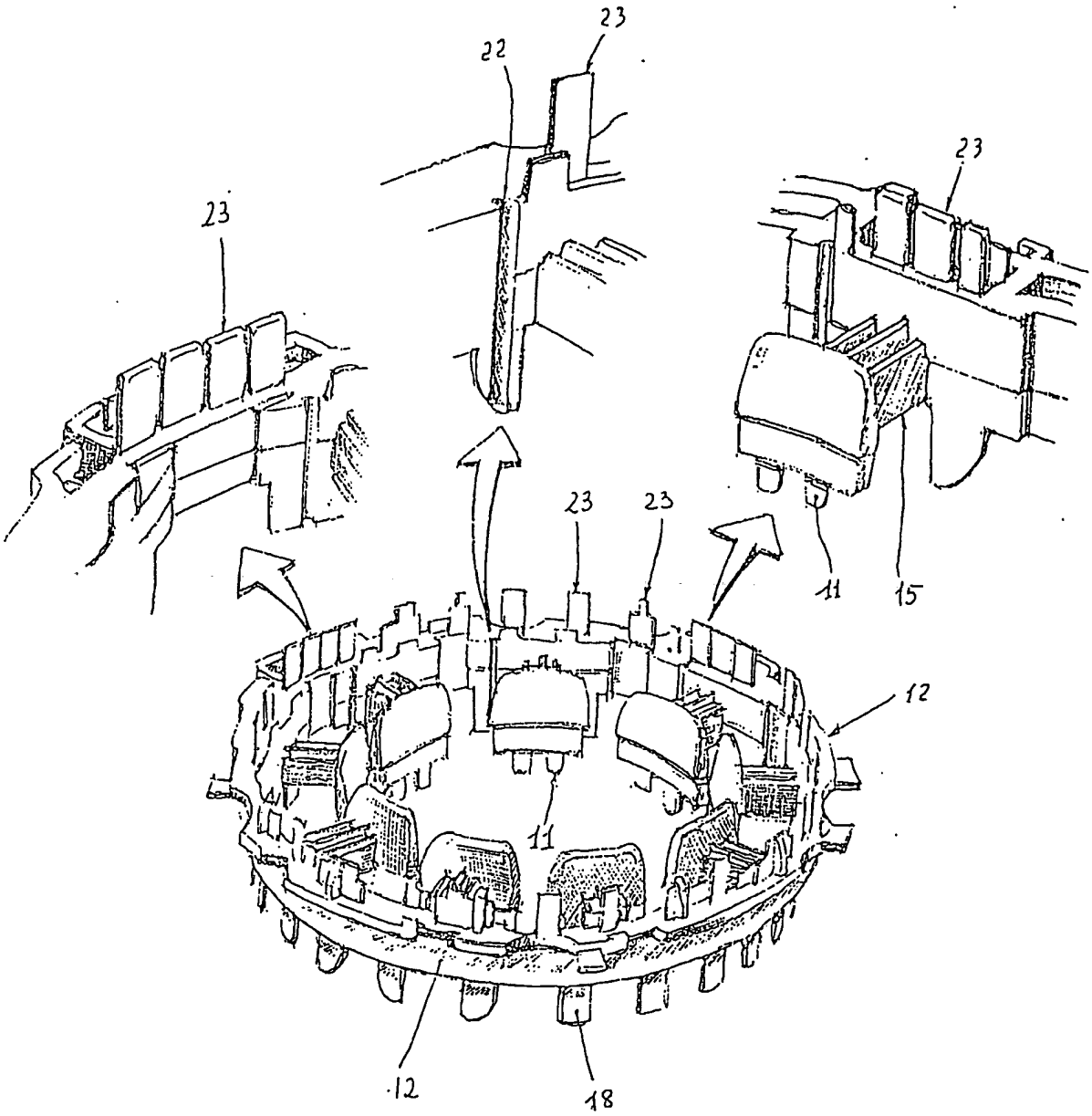


Fig 8

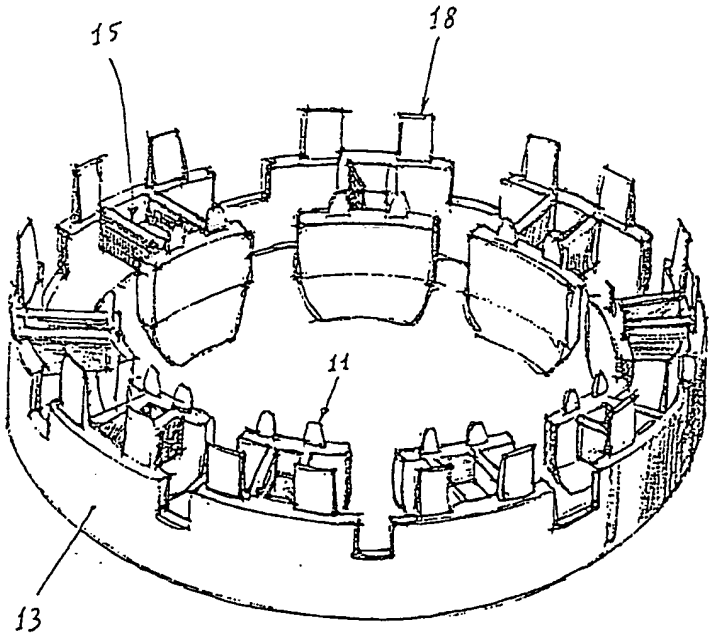


Fig. 9

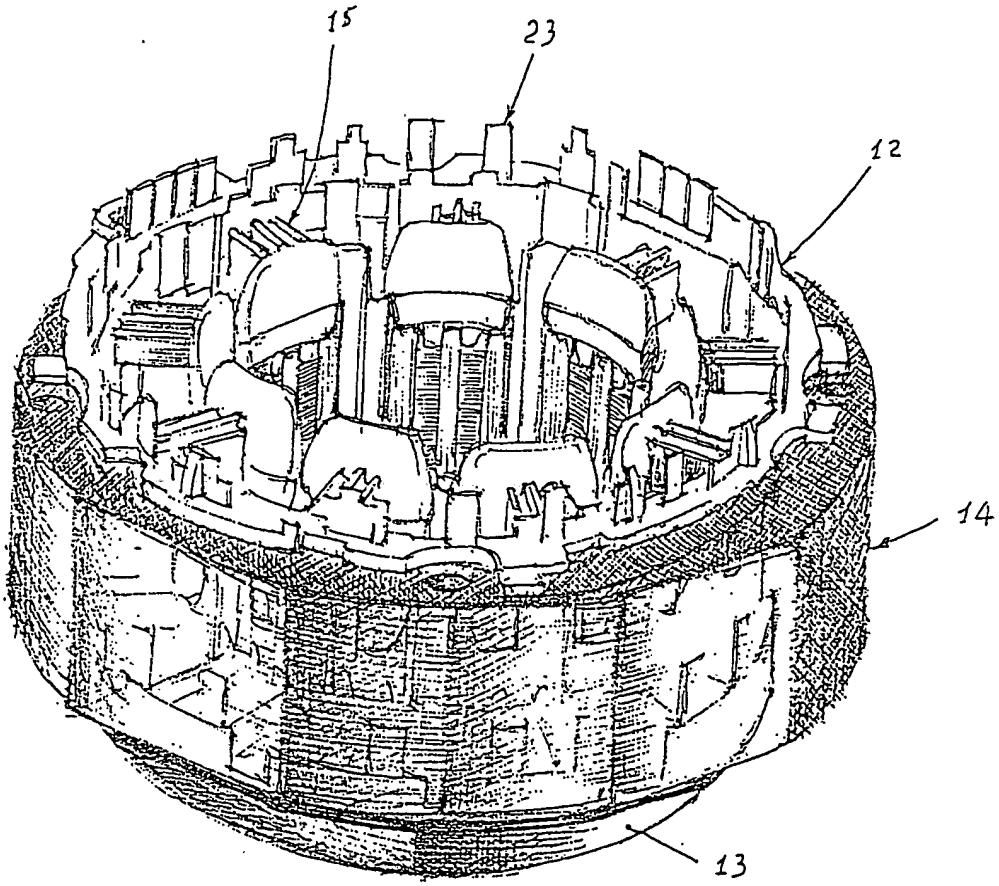
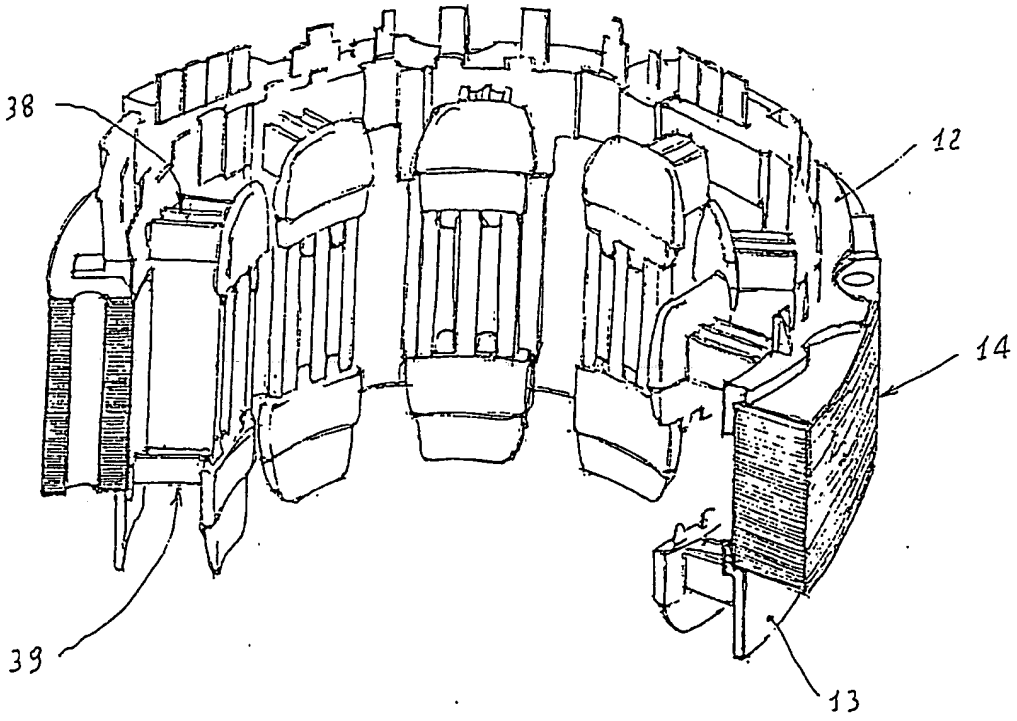


Fig. 10



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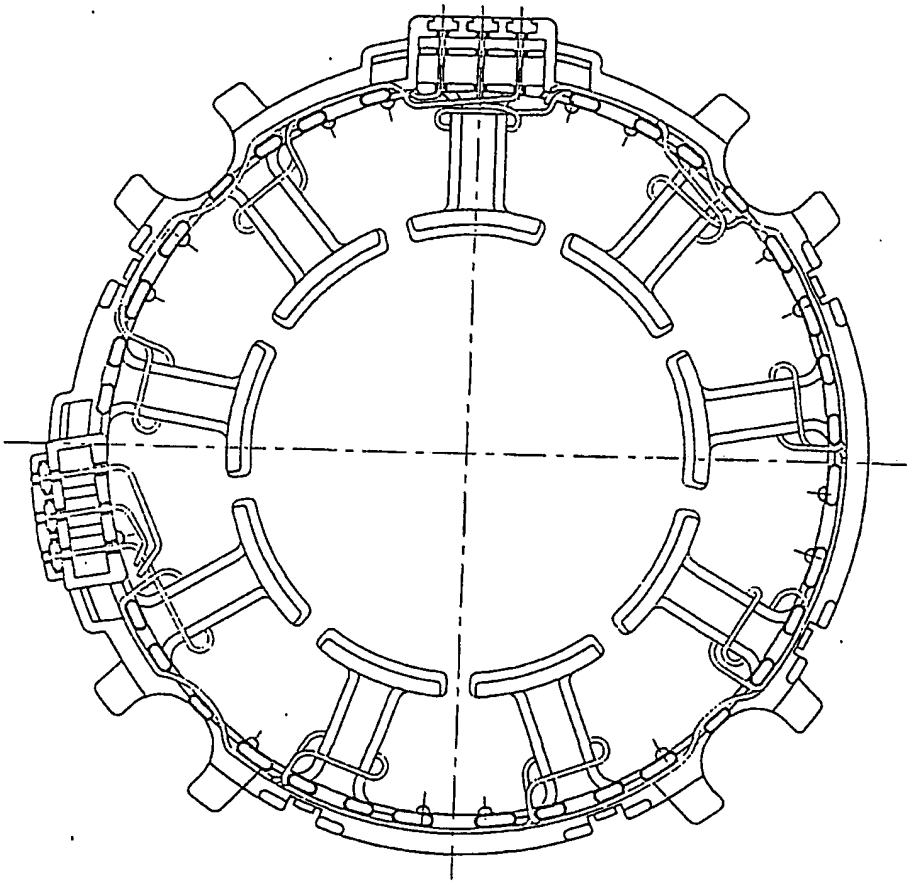

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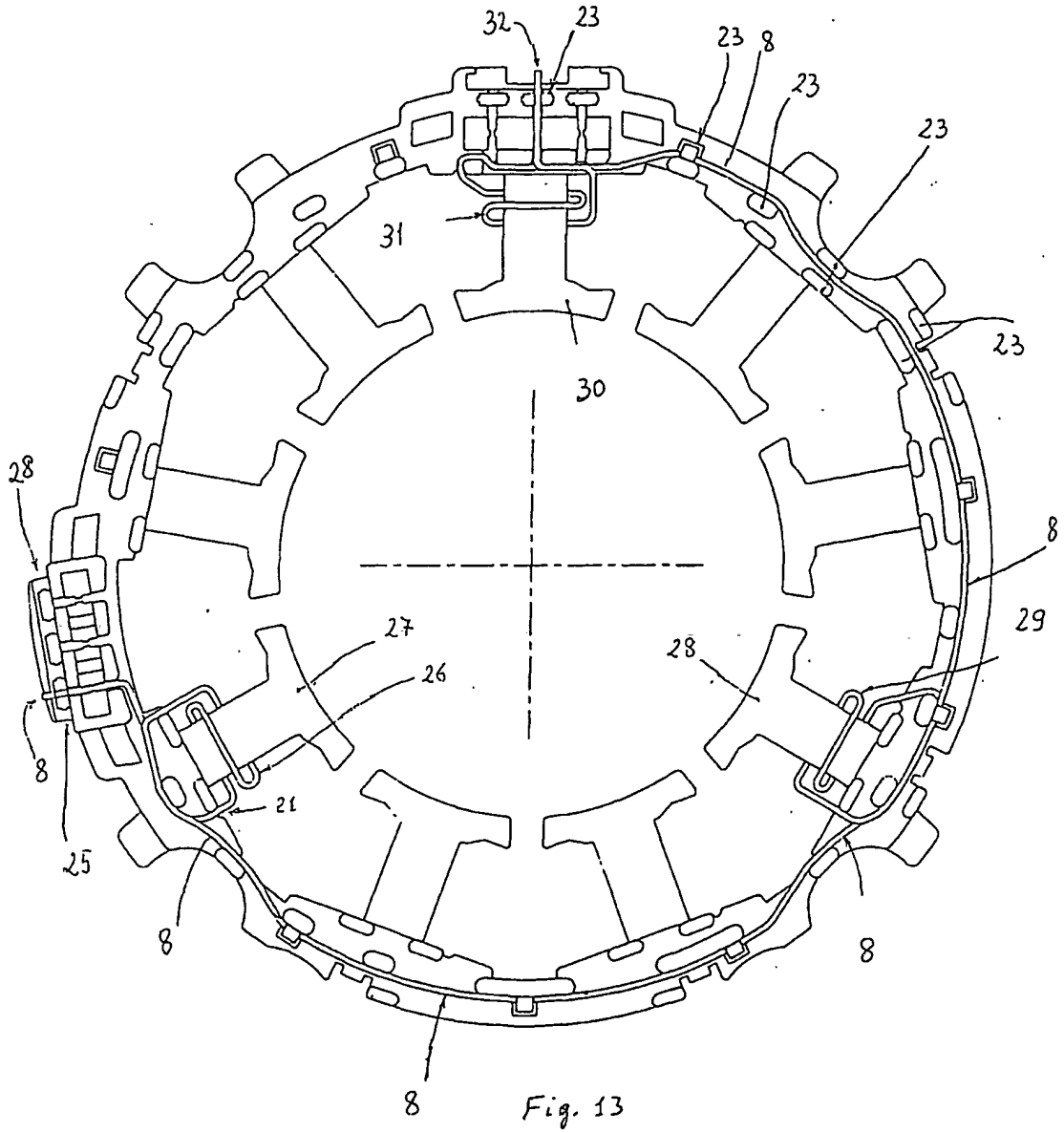


Fig. 13

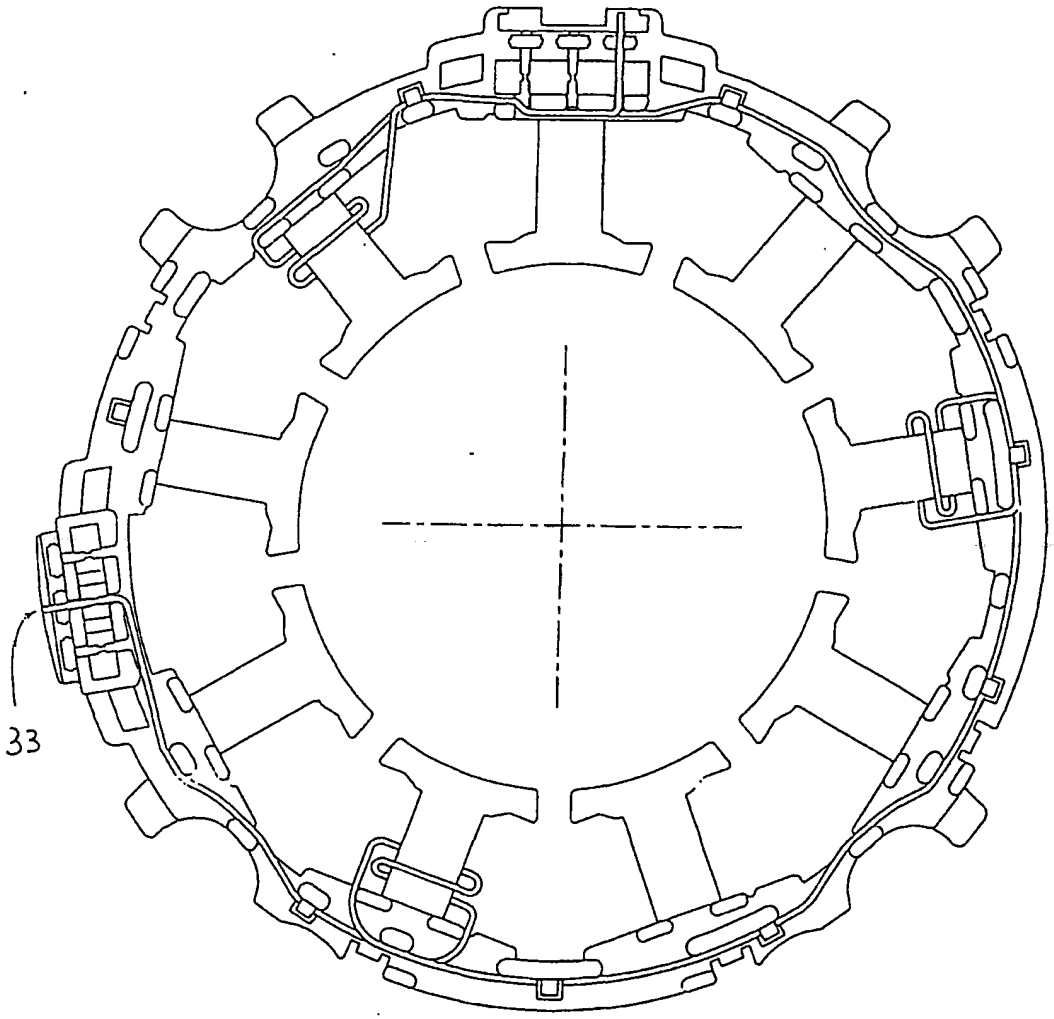


Fig. 14

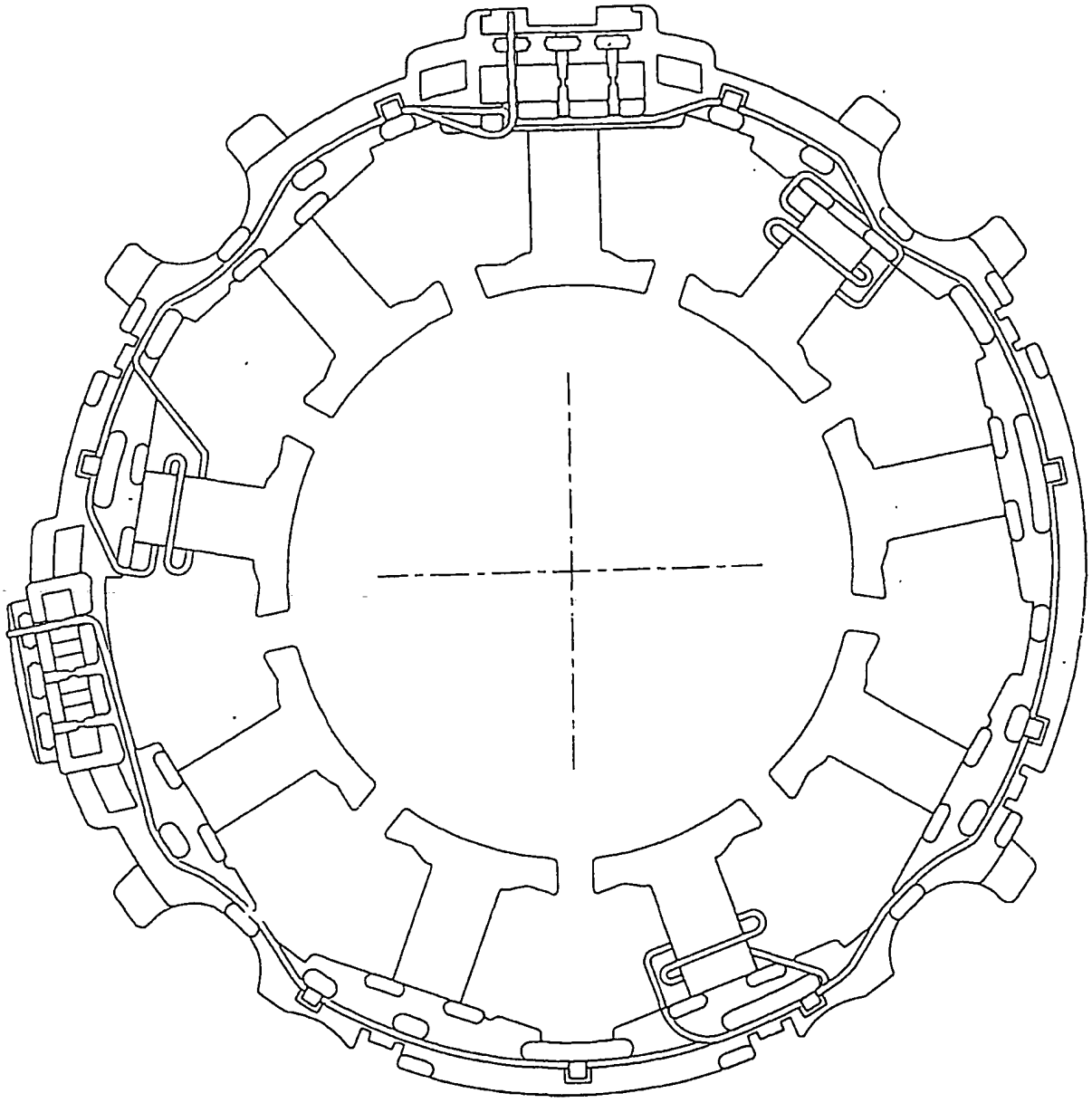


Fig. 15

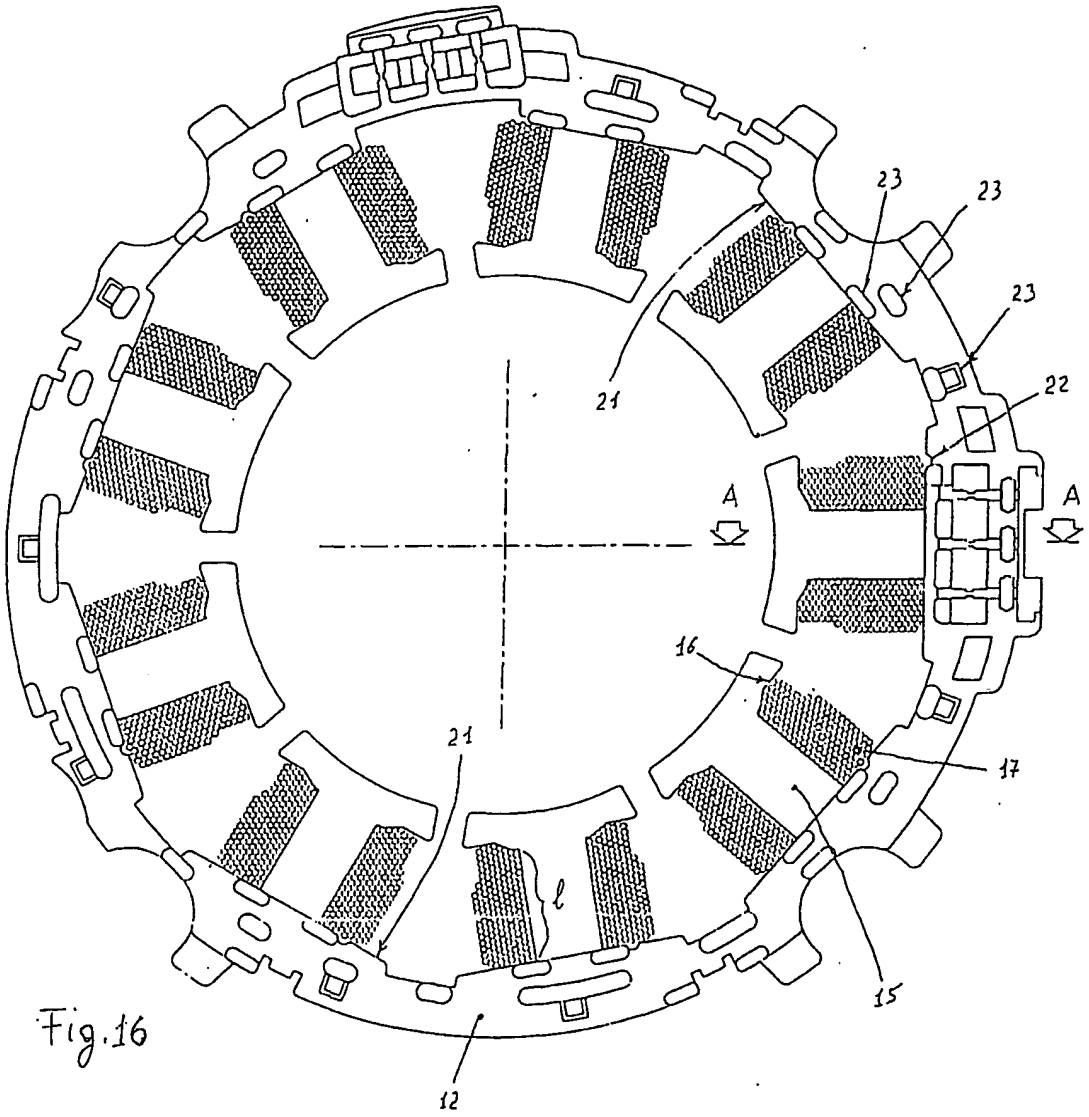
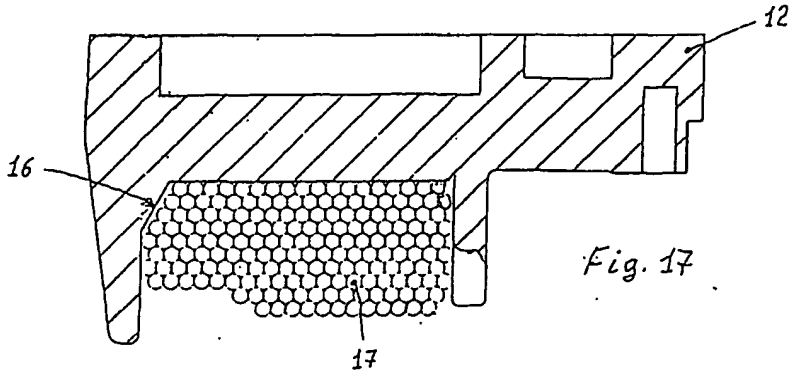


Fig.16



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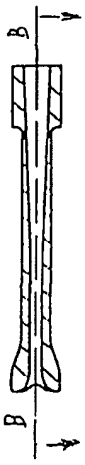

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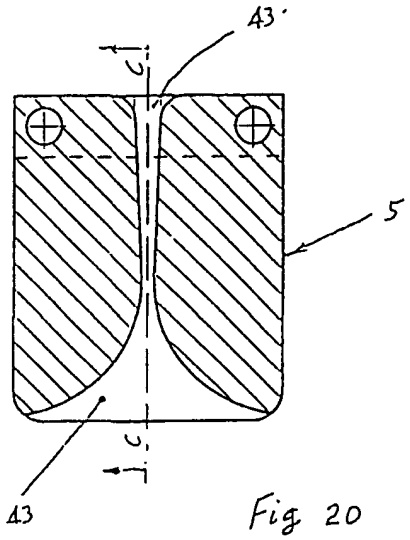


Fig. 20

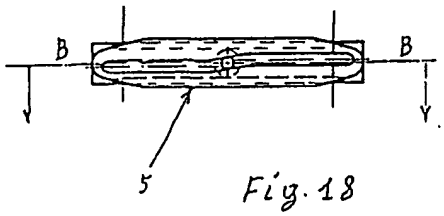
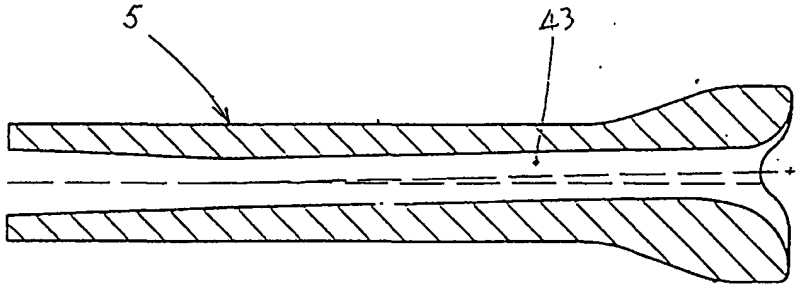


Fig. 18

F3



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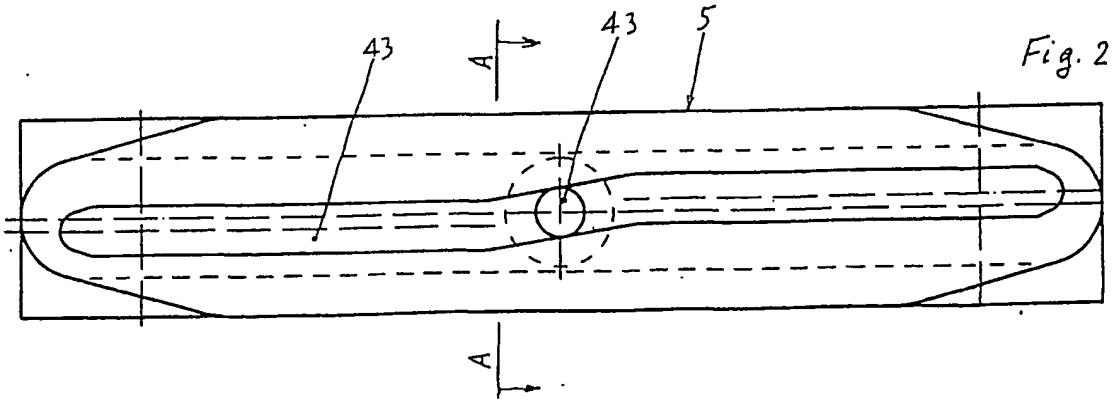

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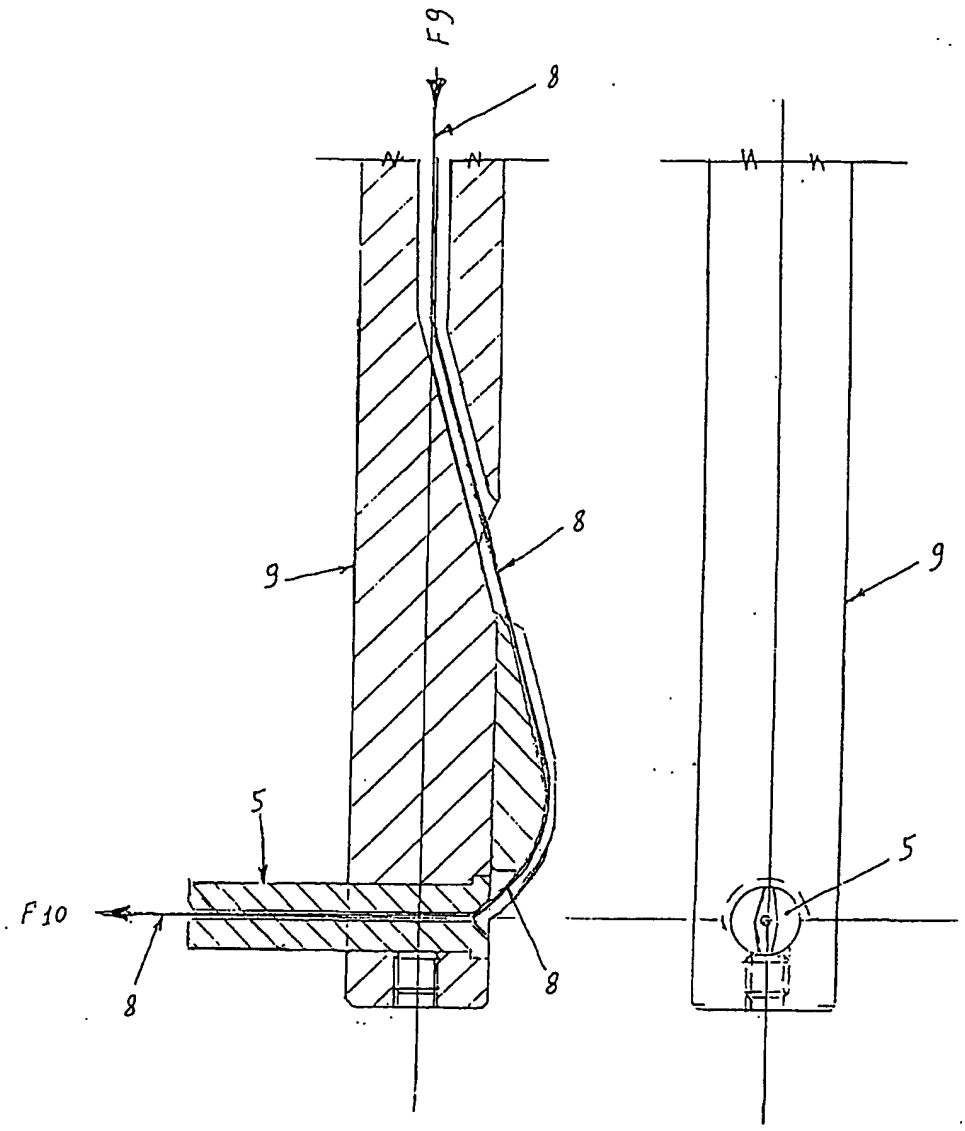

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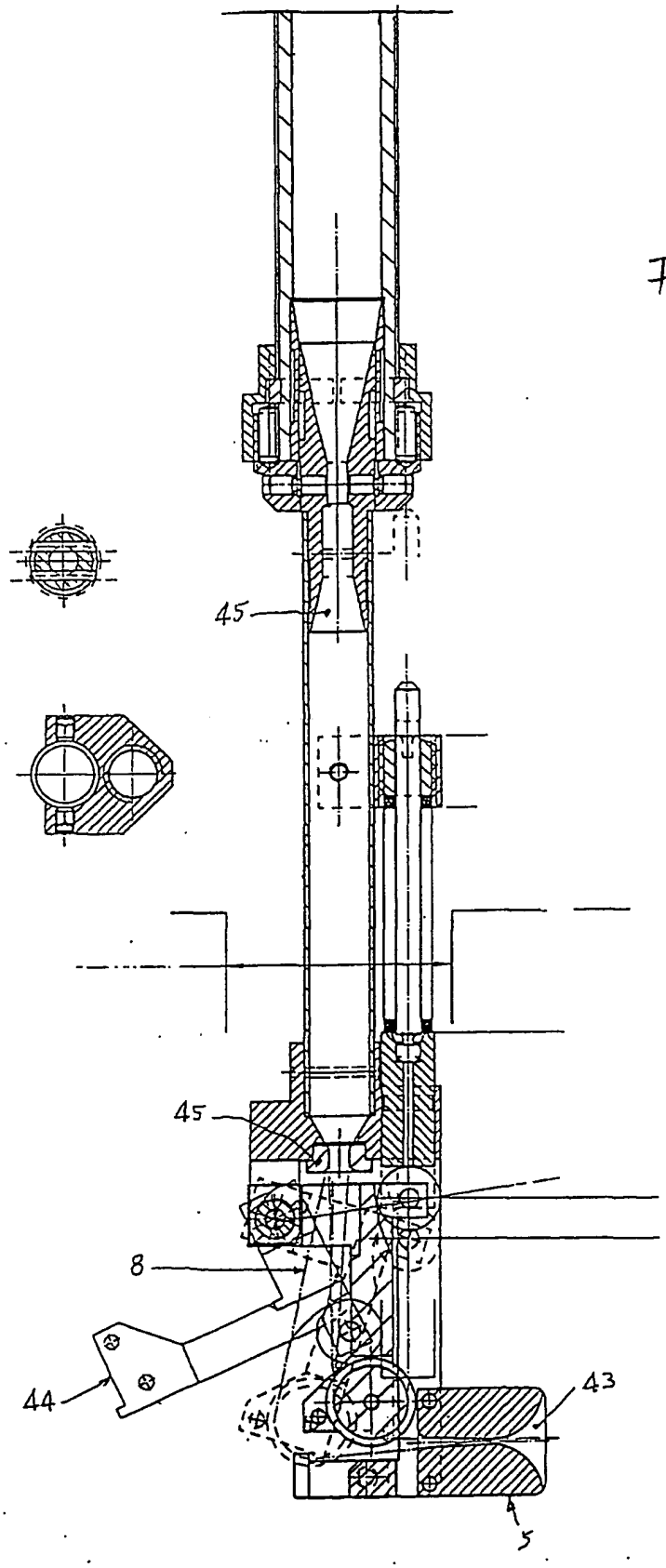
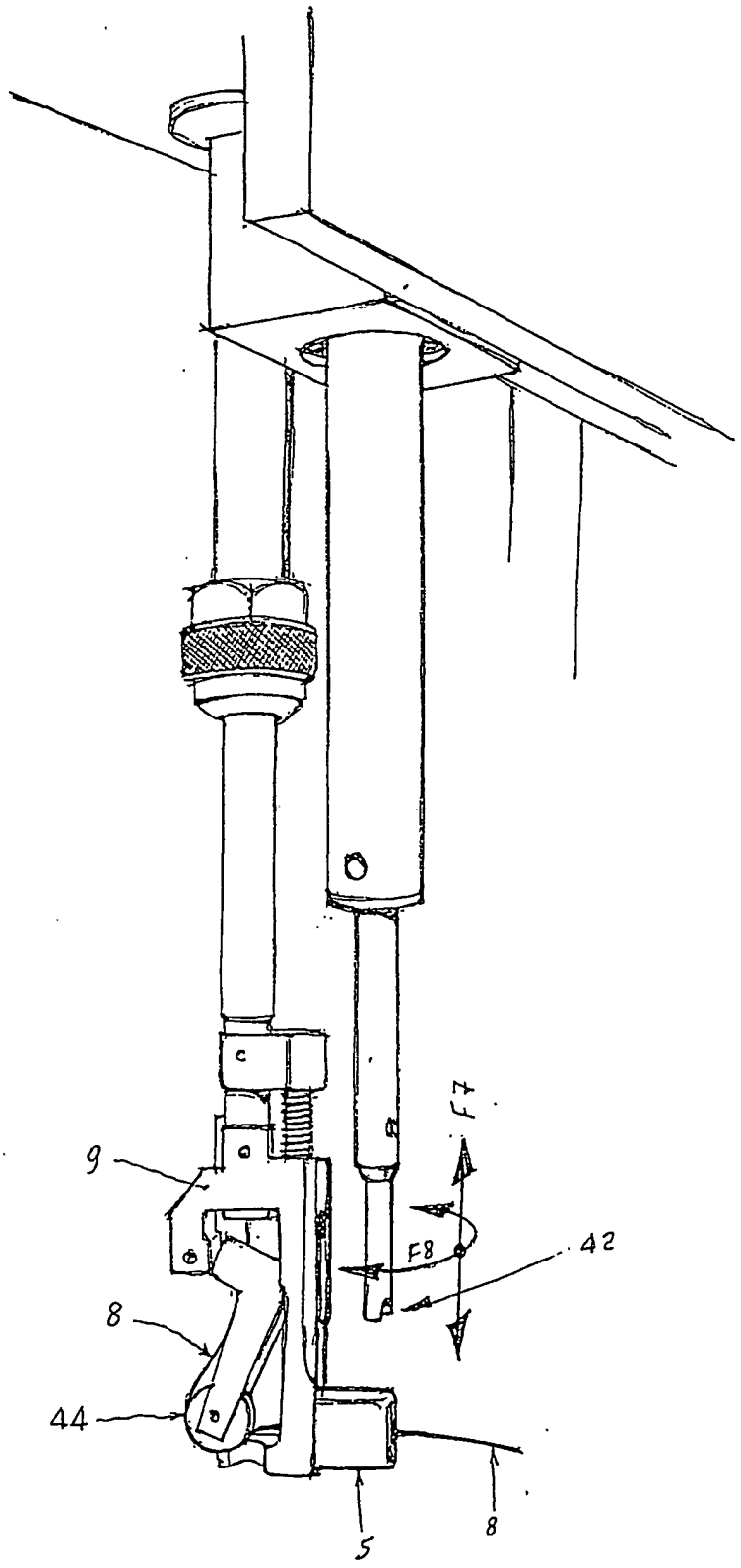


Fig 24



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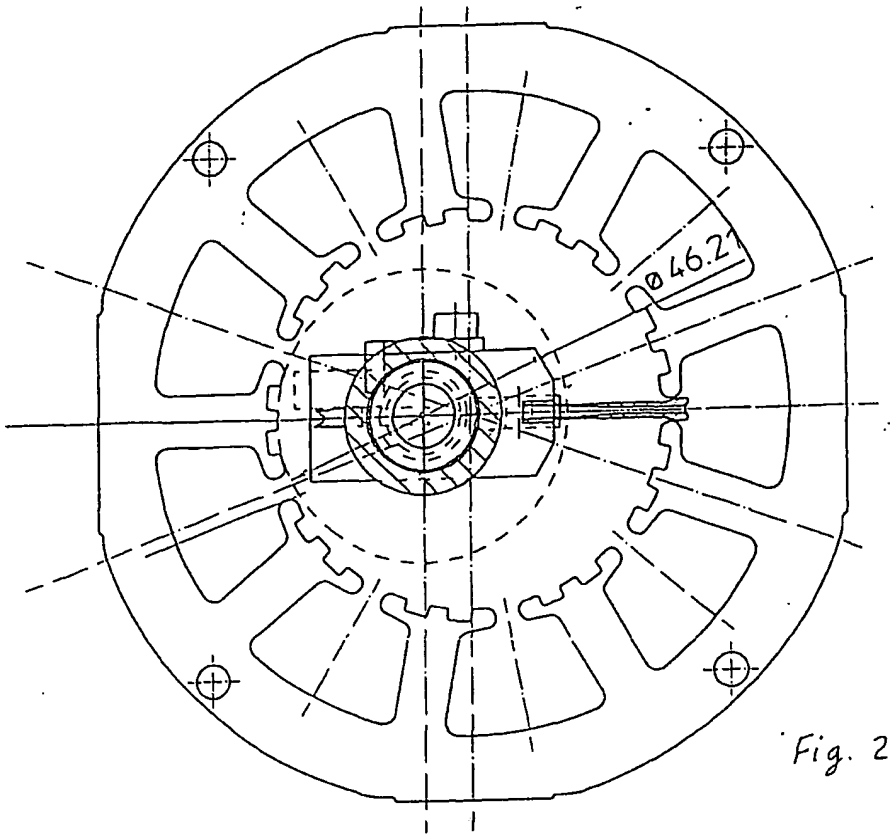


Fig. 26

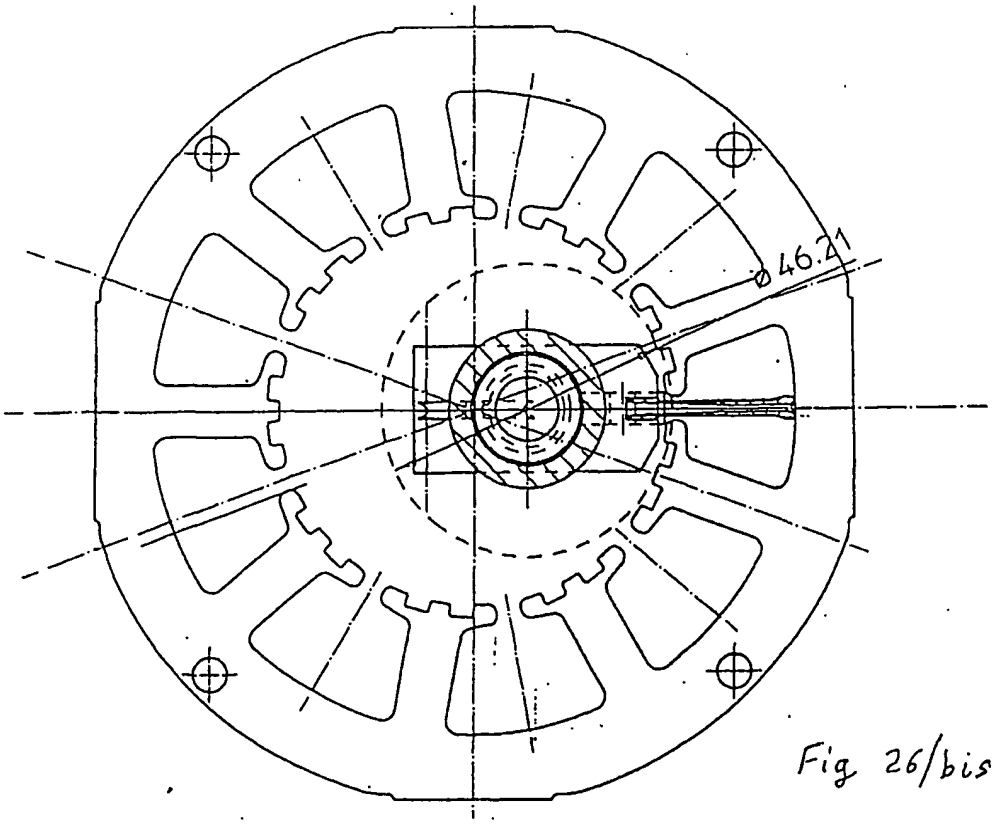


Fig 26/bis

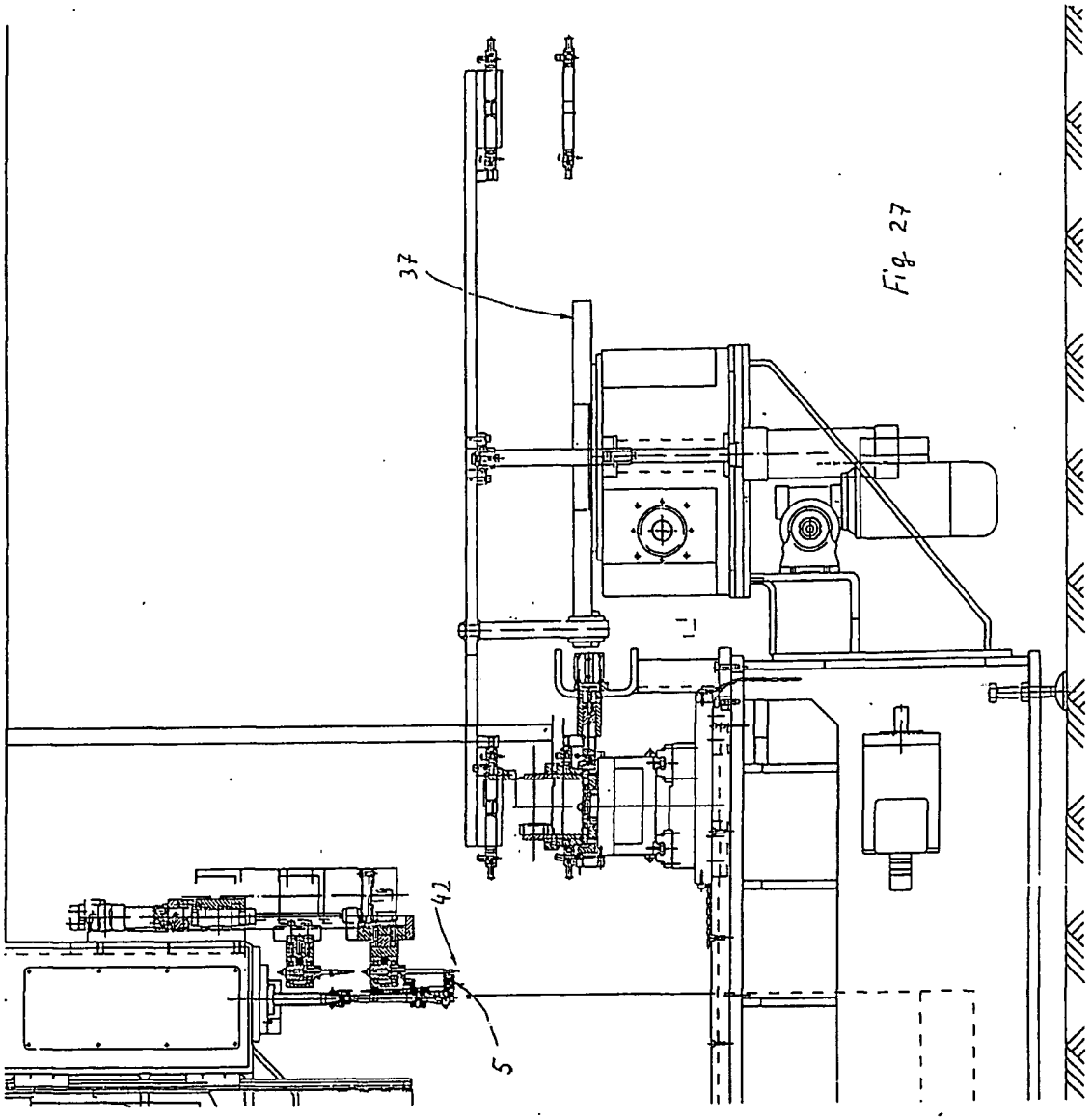


Fig. 27

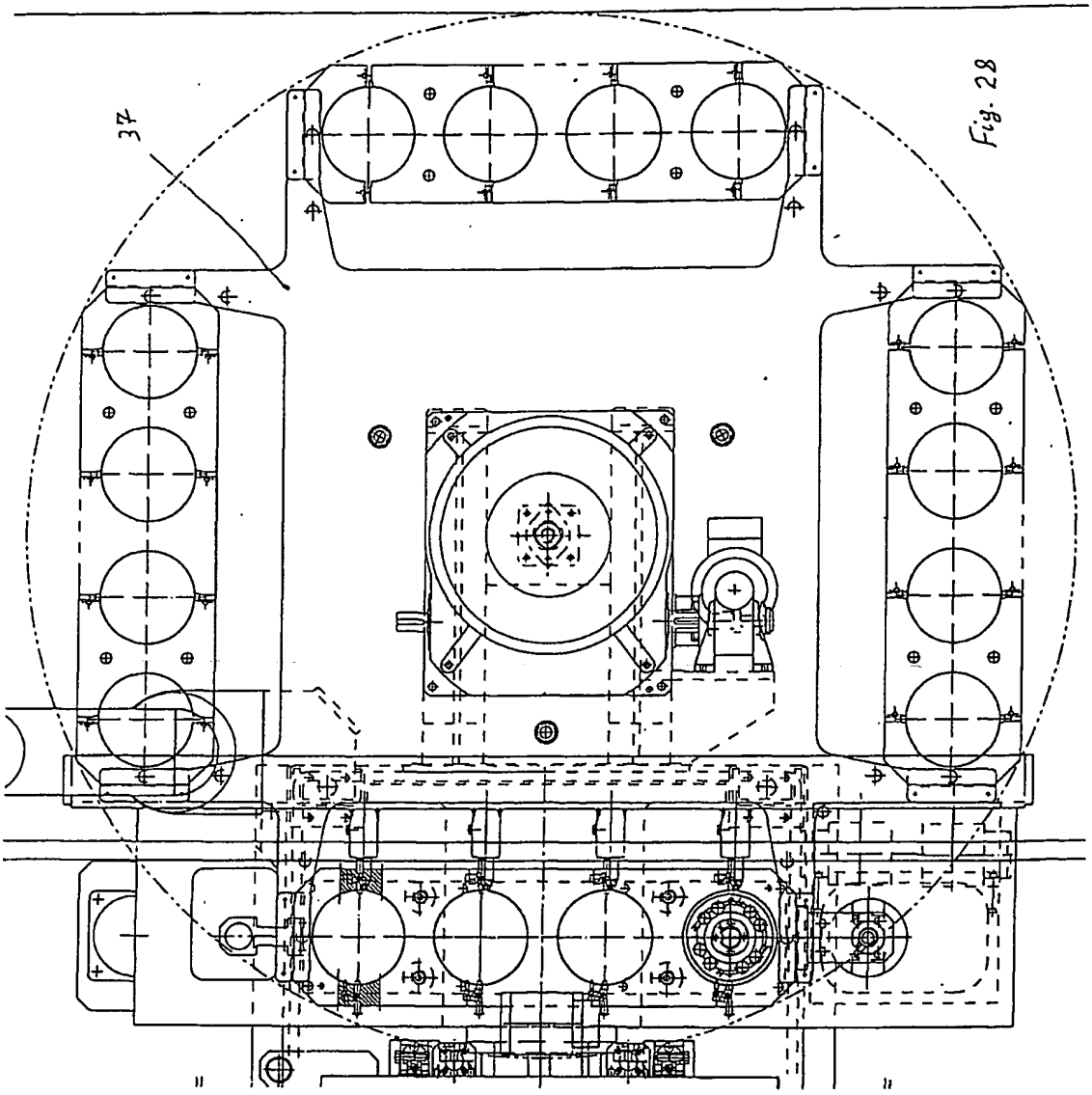


Fig. 28

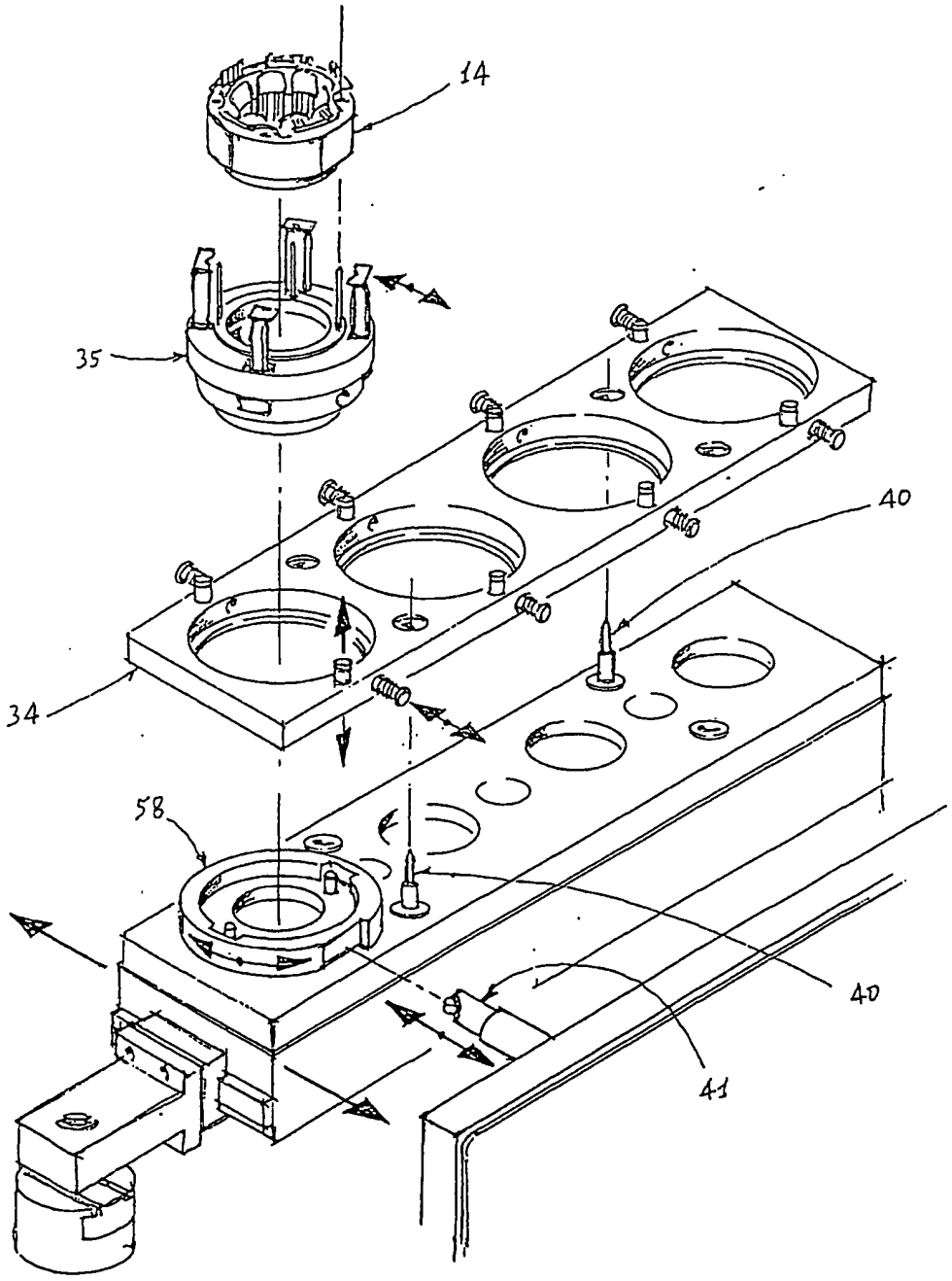


Fig. 29

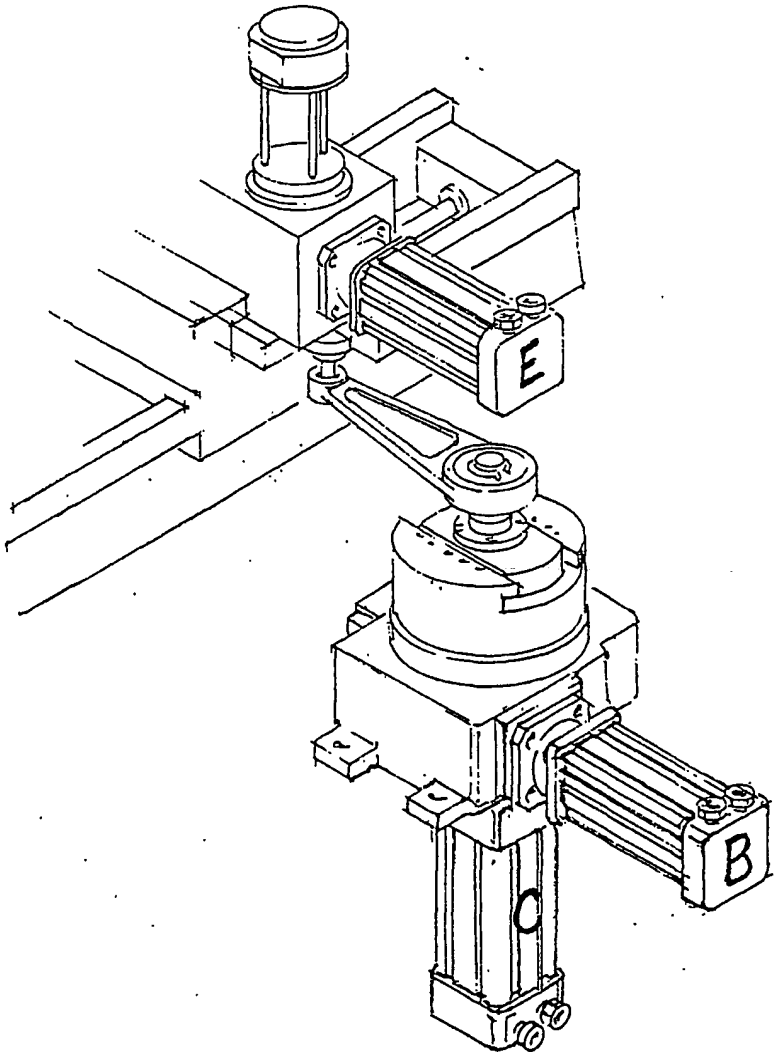


Fig. 30

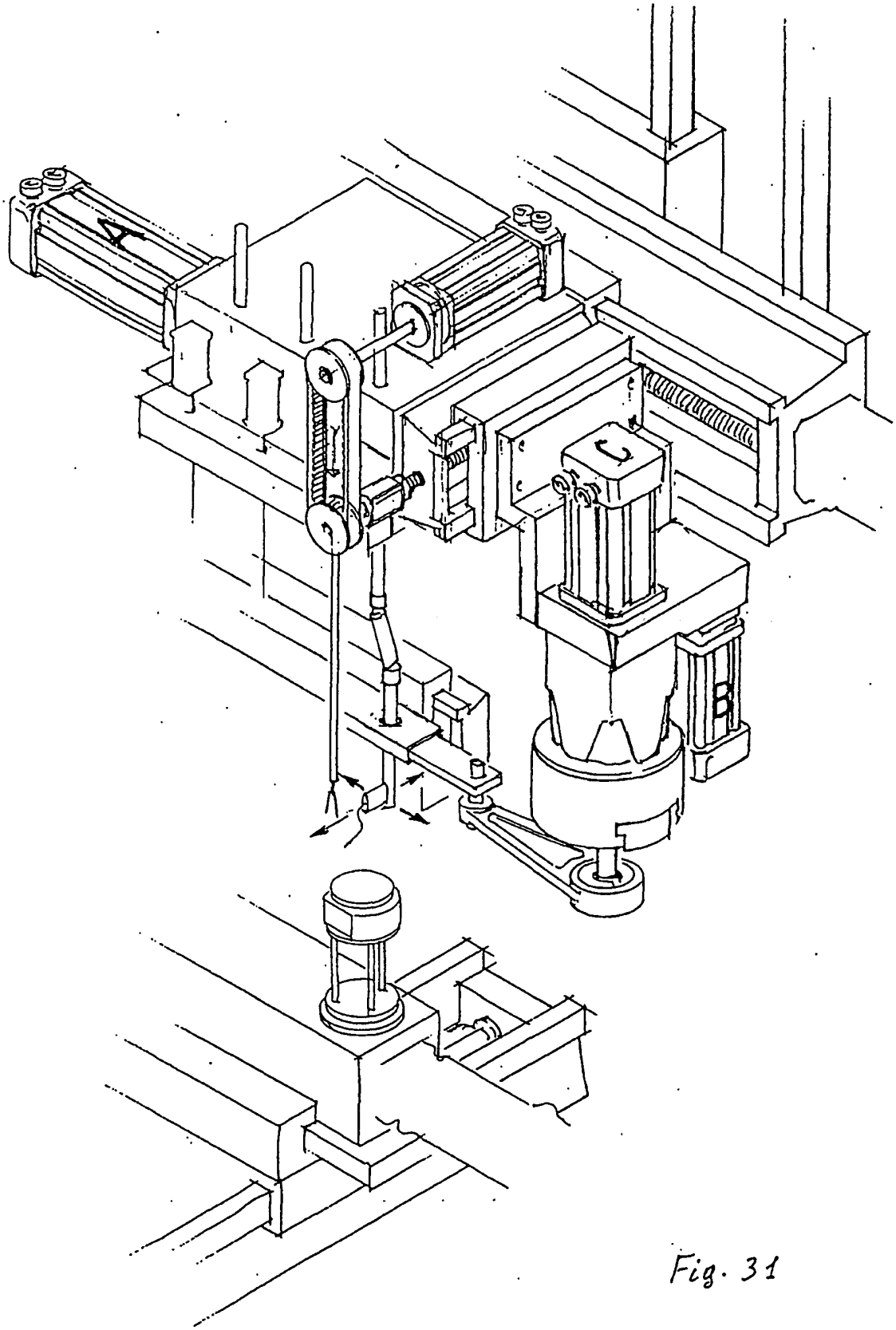
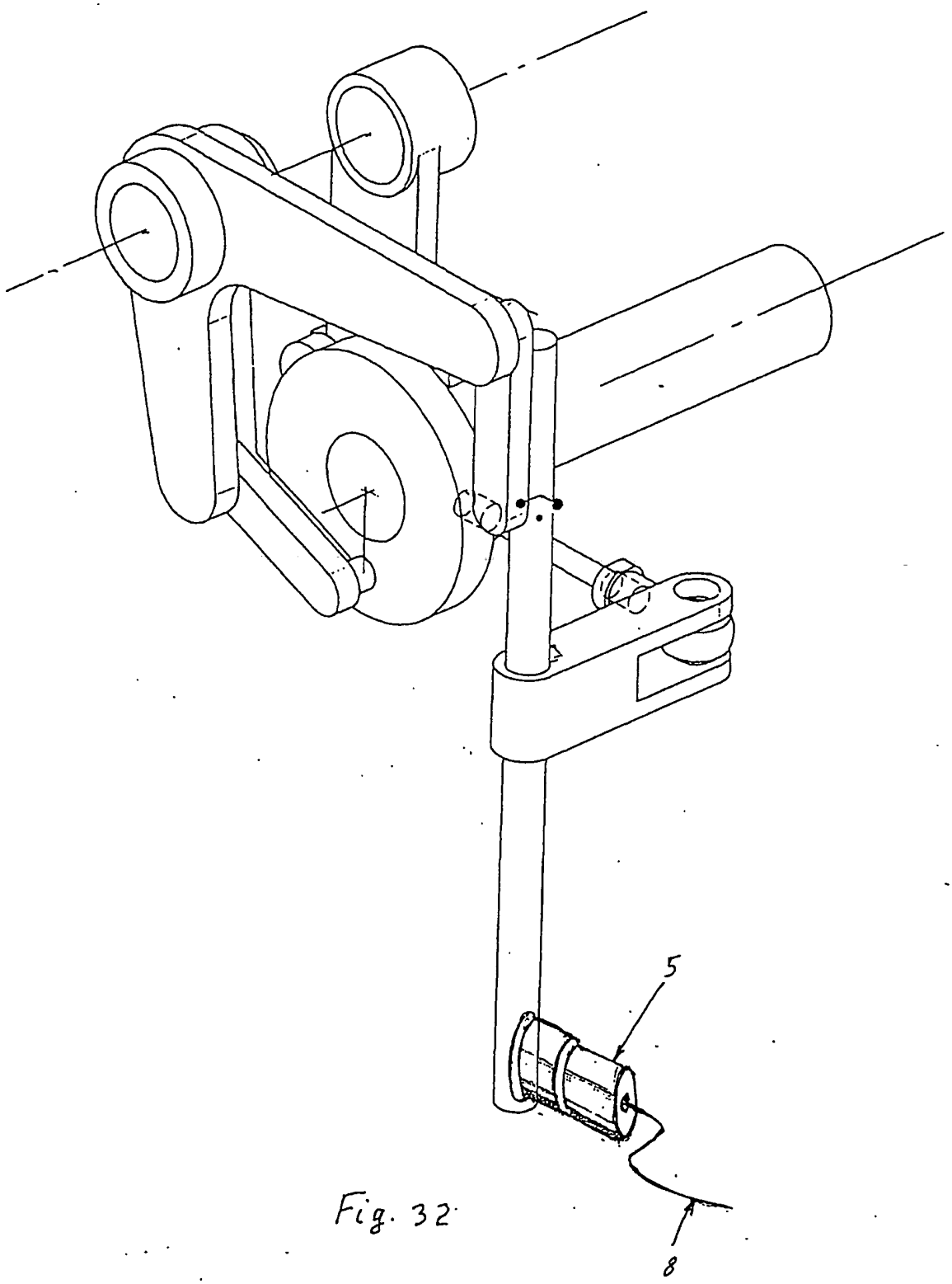


Fig. 31



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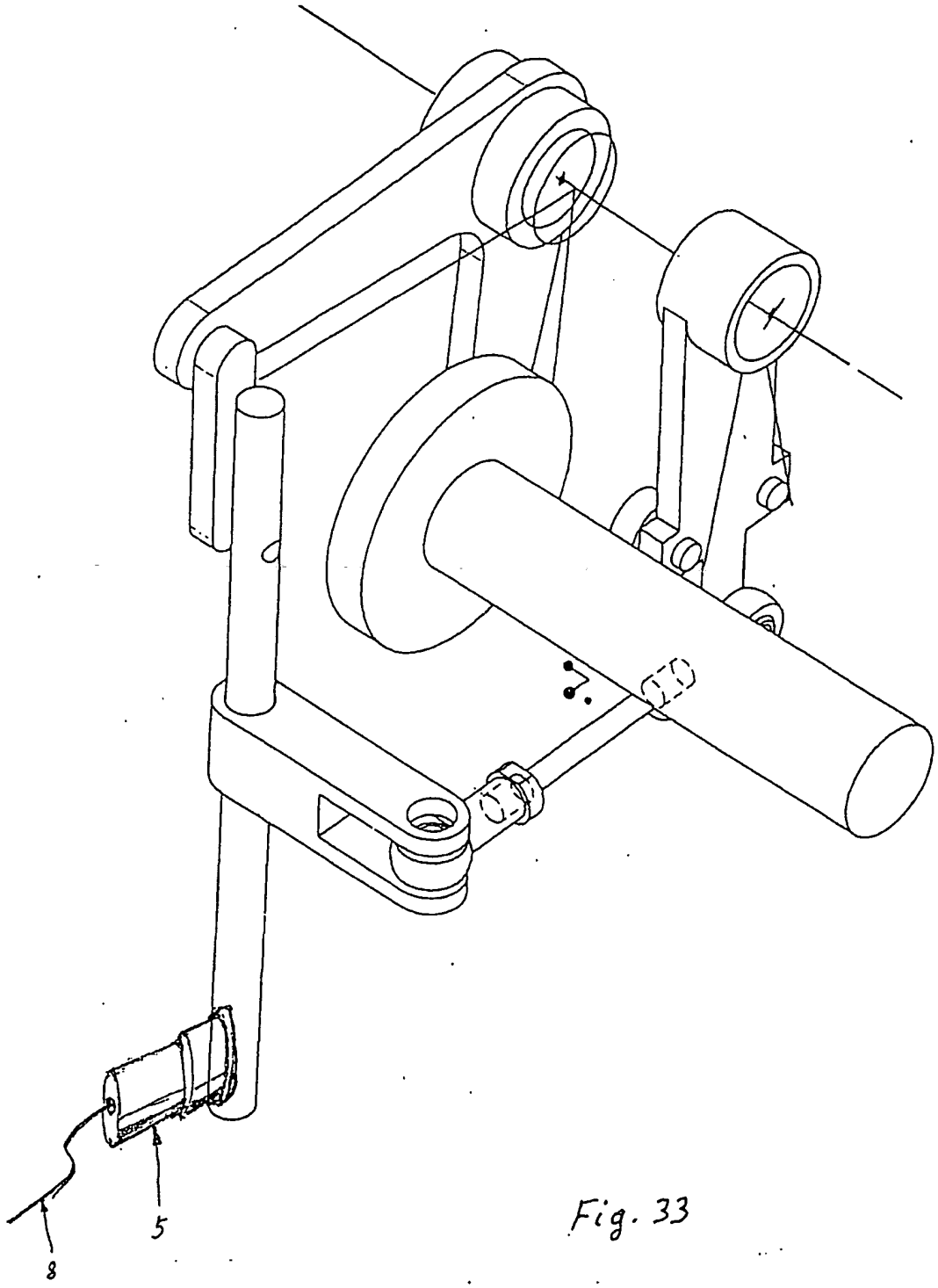

Fig. 33

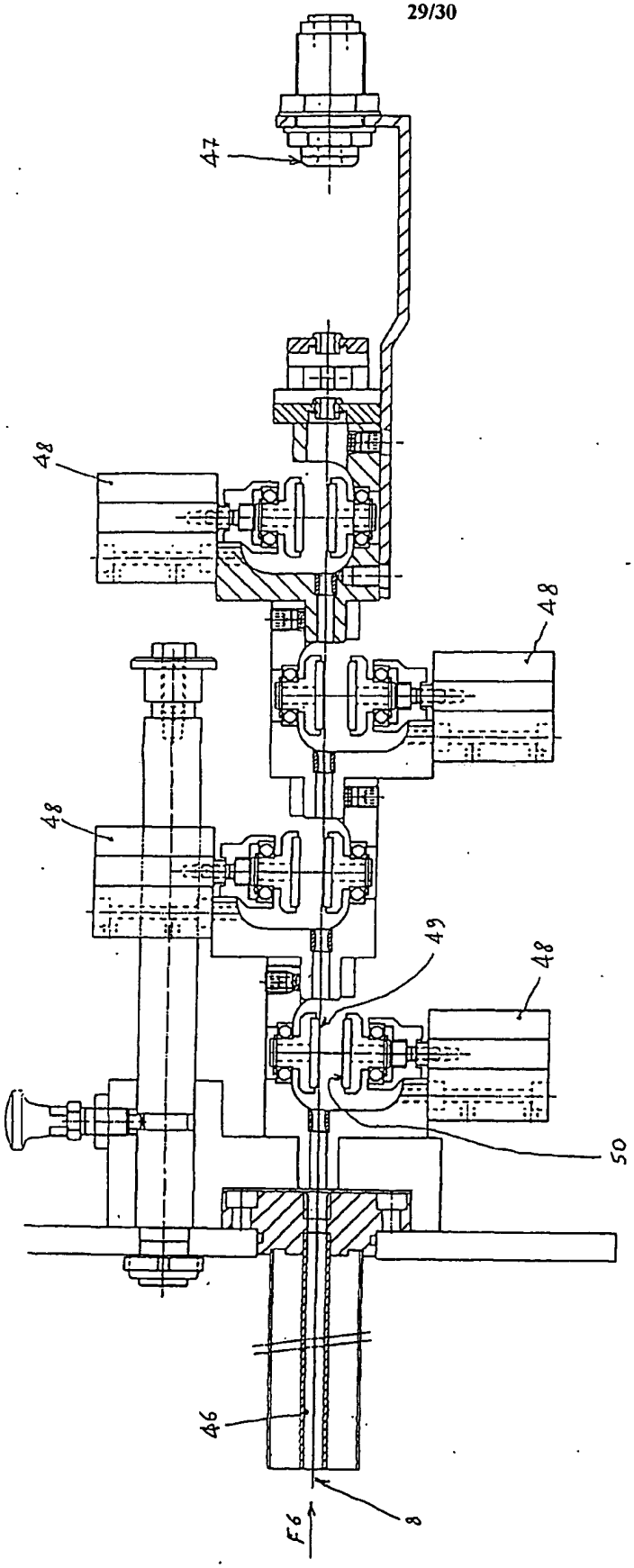

Fig. 34

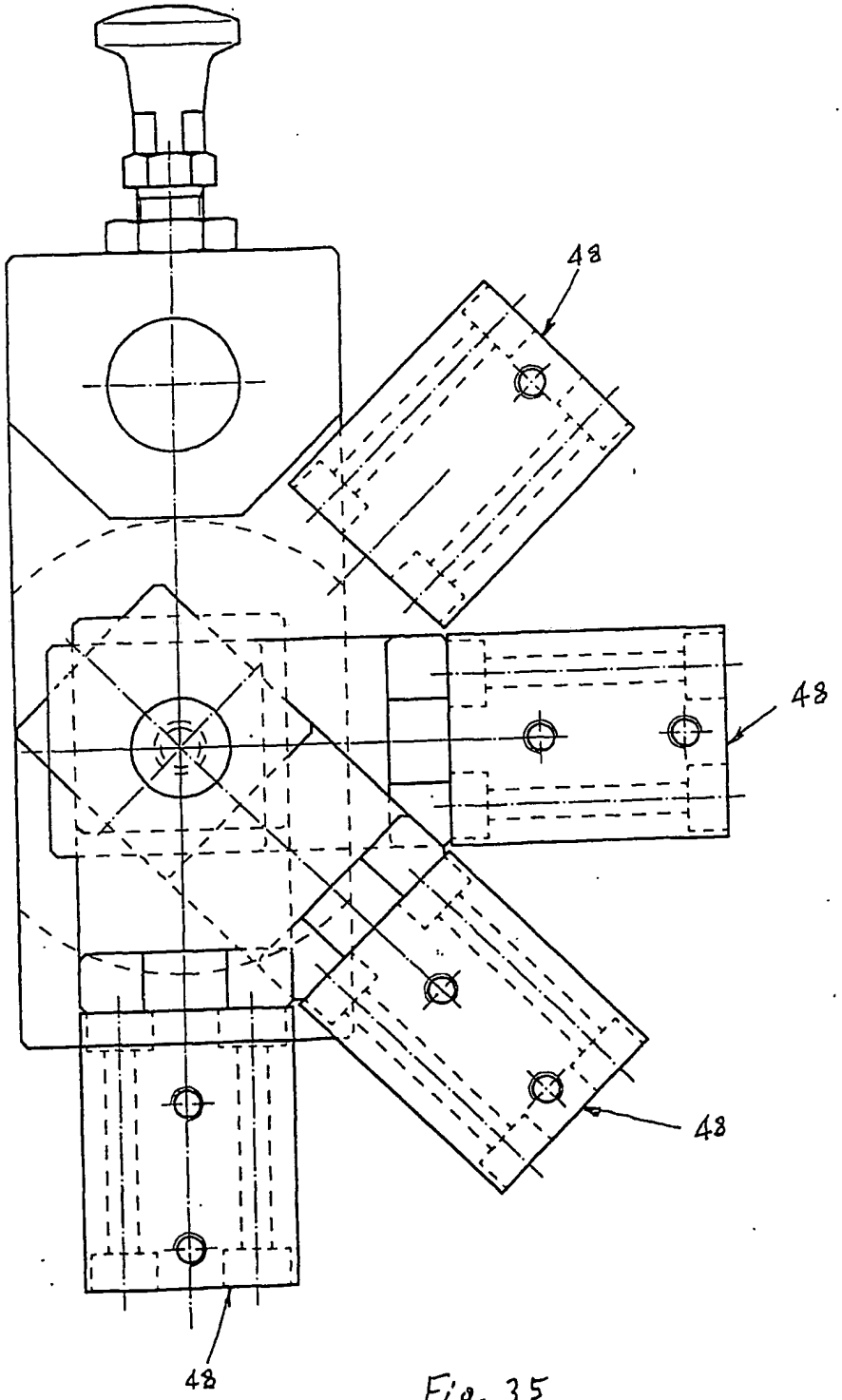

Fig. 35

INTERNATIONAL SEARCH REPORT

h tional Application No
PCT/IT 01/00001

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H02K15/085

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 889 491 A (NITTOKU ENGINEERING CO LTD) 7 January 1999 (1999-01-07) figures 1-3	1
A	US 4 538 770 A (SEDGEWICK RICHARD D) 3 September 1985 (1985-09-03) abstract	1
A	US 4 157 165 A (BIERMAN RICHARD L ET AL) 5 June 1979 (1979-06-05) figure 1	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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Date of the actual completion of the international search	Date of mailing of the international search report
16 May 2001	23/05/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Ramos, H

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/IT 01/00001

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0889491 A	07-01-1999	JP 11027909 A	29-01-1999
		US 6029925 A	29-02-2000
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